Twenty-Sixth Annual Report

OF THE

NEW JERSEY STATE

Agricultural Experiment Station

AND THE

Eighteenth Annual Report

OF THE

New Jersey Agricultural College Experiment Station

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For the Year ending October 31st

1905

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NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS

NEW BRUNSWICK, N. J.

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HARRY W. WILLIAMS, Janitor.

2. AGRICULTURAL COLLEGE STATION. ESTABLISHED 1888.

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The Board of Trustees of Rutgers College in New Jersey.

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AUGUSTA E. MESKE, ... Stenographer and Typewriter.
IRVING E. QUACKENBOSS, ... Assistant Clerk.

THE COLLEGE FARM.

The Trustees of the College give the Stations the use of seven acres of land for experiments in Horticulture and Botany, and the remainder of the farm (90 acres), well stocked and equipped, for experiments in Dairying.

To His Excellency Edward C. Stokes, Governor of the State of New Jersey:

SIR—I have the honor to submit herewith the Twenty-sixth Annual Report of the New Jersey State Agricultural Experiment Station, as required by the law establishing the Station, which was approved March 10th, 1880, and which is chapter 106 of the laws of that year.

DAVID D. DENISE,
President.

NEW BRUNSWICK, N. J., November 30th, 1905.

To His Excellency Edward C. Stokes, Governor of the State of New Jersey:

SIR—In compliance with an act of Congress, approved March 2d, 1887, and with an act of the Legislature of this State, approved March 5th, 1888, I beg leave to submit, on behalf of the Trustees of Rutgers College in New Jersey, maintaining Rutgers Scientific School, the New Jersey State College for the benefit of Agriculture and Mechanic Arts, the Eighteenth Annual Report of the operations of that department of the College which has been organized in accordance with said act of Congress, and is known as "The State Agricultural College Experiment Station."

W. H. S. DEMAREST,
Acting President.

NEW BRUNSWICK, N. J., November 30th, 1905.

TREASURER'S REPORT.

Irving S. Upson, in account with the New Jersey State Agricultural Experiment Station, November 1st, 1904, to October 31st, 1905.

Appropriation for Salaries and Expenses.

RECEIPTS.

From State Treasurer	$20,000 00

PAYMENTS.

Salaries and Pay of Chemists and Assistants	$12,238 28
Expenses of Board of Managers	31 90
Stationery	167 98
Printing	175 25
Postage, Telephone and Telegraph Service	312 31
Furniture	83 05
Fuel	1,072 39
Gas, Electricity and Water	266 47
Laboratory Expenses	978 95
Field and Feeding Experiment Expenses	2,820 26
Freight, Express and Cartage	128 27
Expenses Collecting Samples of Fertilizers	245 42
Traveling Expenses	369 80
General Fittings, Repairs and Improvements	852 94
Insurance	95 09
Reference Books	128 64
Contingent Expenses	33 00
Total	$20,000 00

Appropriation for Carrying Out the Provisions of "An Act Concerning the Regulation of the Sale of Concentrated Commercial Feeding Stuffs."

RECEIPTS.

From State Treasurer	$3,000 00

PAYMENTS.

Salaries and Pay of Chemists and Assistants	$2,593 26
Laboratory Fittings, Apparatus and Supplies	276 22
Expenses Collecting Samples of Feeding Stuffs	130 52
Total	$3,000 00

Appropriation for Printing Bulletins.

RECEIPTS.

From State Treasurer	$1,500 00

PAYMENTS.

For Printing Bulletins	*$1,500 00*

Appropriation for the Purpose of Carrying Into Effect "An Act to Provide for an Investigation and Report by the New Jersey Agricultural Experiment Station Upon the Mosquito Problem, in its Relation to the Sanitary, Agricultural and Other Interests of the State."

RECEIPTS.

From State Treasurer	$2,500 00

PAYMENTS.

Salaries and Compensation of Assistants	$2,000 00
Labor	56 00
Laboratory and Field Apparatus and Supplies	39 52
Freight and Express	1 60
Traveling Expenses	402 88
Total	$2,500 00

The Auditing Committee of the Experiment Station has examined the accounts of the Treasurer of said Station, and has found them correct.

JOHN E. DARNELL,
GEORGE E. DE CAMP,
Auditing Committee.

FINANCIAL STATEMENT.

The Trustees of Rutgers College
for
The New Jersey State Agricultural College Experiment Station
in account with
The United States Appropriation, 1904-1905.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30th, 1905, as per act of Congress, approved March 2d, 1887		$15,000 00
By Salaries	$9,730 00	
Labor	1,062 32	
Publications	790 16	
Postage and Stationery	502 98	
Freight and Express	116 69	
Heat, Light and Water	417 45	
Chemical Supplies	163 40	
Seeds, Plants and Sundry Supplies	190 08	
Fertilizers	70 05	
Feeding Stuffs	......	
Library	509 07	
Tools, Implements and Machinery	187 87	
Furniture and Fixtures	162 56	
Scientific Apparatus	287 51	
Live Stock	......	
Traveling Expenses	260 43	
Contingent Expenses	233 00	
Building and Repairs	316 43	
Total		$15,000 00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the New Jersey State Agricultural College Experiment Station for the fiscal year ending June 30th, 1905, that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct, thus leaving no unexpended balance.

And we further certify that the expenditures have been solely for the purpose set forth in the act of Congress, approved March 2d, 1887.

(Signed) W. H. S. DEMAREST,
EDWARD B. VOORHEES,
Auditors.

REPORT OF THE DIRECTOR.

REPORT OF THE DIRECTOR.

The work of the Experiment Stations during the past year has been enlarged materially, mainly in two directions, namely, in the Horticultural department and in the enlargement of the facilities for carrying on the experiments in plant nutrition, though the scope of the work in the Departments of Botany and Entomology has been broadened. Special reference to the character of the work in these directions will be made in the reports of these departments.

Examination of Fertilizers.

In the prosecution of the fertilizer control, 420 samples of complete fertilizers, representing ninety-six manufacturers, were analysed. The analyses of these show considerable variations from the guarantee, greater, on the whole, than has been the case in past years and may be due in many instances to the attempts of the manufacturers to maintain the standards and selling prices of previous years, notwithstanding the increased cost of raw materials. An examination of different samples of the same brand also showed that the materials used in the preparation of those of the same name and guarantee differed widely. For example, in samples containing the same percentage of nitrogen it has been derived, in some cases, entirely from organic matter, while in others nitrates or ammonia salts, or both, have been the source of supply of a part of the nitrogen. This, while not changing the total content, would affect the "availability" of the nitrogen and thus cause a variation in results when used under the same conditions. In other cases wide variations in the composition of duplicate samples of the same brand have been shown. Whatever may have been the cause of these irregularities, the fact that they do exist not only increases the necessity for a closer inspection but makes the published results less uniformly useful than would be the case if the same brands, sold in different parts of the State, were made from the same kinds, amounts and proportions of materials.

The method of inspection followed has, as in the past, continued to give entire satisfaction. The inspector visits those sections of the State, using fertilizers in large quantities early in the season first, and since the work requires at least two months, it is late in May when the districts of less consumption are visited, and in some cases stocks are exhausted. This can hardly be avoided and does not as a rule reduce the number of individual brands received.

Incomplete Fertilizers and Special Mixtures.

In addition to the number of complete fertilizers received there were 204 samples, representing home mixtures, specially prepared mixtures, fertilizing materials and ground bones, analysed. These were, as a rule, found to be as represented and show very clearly the advantage to the farmer of purchasing supplies from original sources, especially when large quantities are used, as the cost of the constituents is reduced, besides the farmer possesses definite knowledge as to the quality of the different constitutents.

Analyses of Commercial Feeds.

Four hundred and forty-nine samples of commercial feeds were taken by the inspector, of which 397 were analysed. The samples requiring guarantee represented 159 different brands; fourteen of these were devoid of information as to to their composition. This is 9 per cent. of the total number, and while slightly greater than the number deficient last year, nevertheless shows the desire on the part of the manufacturer to comply with the law. With the exception of the feeds derived from corn and linseed meal, the quality was of a high order, reaching or exceeding their guarantees. A number of deficiencies occurred in the distillery and brewery products, because in certain cases guarantees were rather high for this class of materials, but the chief cause is due to the difficulty of maintaining uniformity in products of this class. The main point is that the deficiencies as a rule do not arise from inferiority of the feeds, as their average protein content is fully as high as heretofore. Nine samples of the feeds examined were unquestionably adulterated; seven of these were linseed meal, from one source of supply, and contained cocoa shells in varying quantities; one sample of dried brewers' grains contained coffee hulls, and a sample of mixed feed contained an excess of corn-

cob. These infringements of the law were reported to the proper authorities.

Thirty-one brands examined were either new to the State or had not been previously completely studied, among which are several of great promise, and a few which should be scrupulously avoided. Cocoanut cake is a comparatively new feed in this country and possesses characteristics which make it a valuable addition to the list of concentrates. Those which should be avoided are mainly products derived in the handling of peanuts and of rice. In the case of the peanut products, the fiber content ranges from 48 to 65 per cent.; these should be avoided as being dangerous to the health of animals. The same is true of a number of feeds which contain the refuse products obtained in the preparation of rice. These feeds contain more or less of the hulls, which possess but little nutritive value and are liable to be positively dangerous when fed in large quantities. Many reports of injury from feeding these products have been noted in other States.

A Study of Condimental Feeds and Condition Powders.

During the past year a bulletin was issued on this subject which contained in addition to the analyses, a detailed description of many of the materials which entered into the manufacture of condimental feeds and condition powders. This study required a considerable amount of work aside from that involved in the chemical analyses, many of which were very complex. The bulletin also included a brief review of the results obtained from the use of these materials in this and other countries. It is altogether one of the most important lines of study carried out by the Station. The bulletin contained the analyses of fifty brands, twenty-three of which had not been previously reported by any Experiment Station, and the results of the study showed clearly that the claims of manufacturers are not reliable; but even assuming that the feeds are scientifically prepared mixtures of useful and effective ingredients, and that their use as directed would confer upon the animal the benefits claimed, their excessive cost would prohibit their use by the careful and economical feeder. Such ingredients, which they contain and which might be of benefit, any feeder can obtain and mix for himself at from one-tenth to one-twentieth the cost of the prepared brands.

A chemical investigation of the carbohydrate group of nutrients is also in progress in this department.

Plant Nutrition.

As already indicated, this line of work has been very largely increased the past year. The plan adopted contemplates a rather comprehensive study of the needs of plant-food of certain well-defined soil types, and also the mineral needs of soil in respect to the growth and development of legumes. In the prosecution of this work a new scheme was devised for conducting the experiments by the pot system, one which, while experimental in a way, has resulted in giving excellent results the first season. The broadening of the lines of work in this direction adds very materially to the laboratory work, as all plant studies are controlled by analyses. The experiments in progress for the past seven years have been continued, and the results are of great interest and value. Bulletin No. 180, entitled "Experiments on the Accumulation and Utilization of Atmospheric Nitrogen in the Soil," was published in March, giving the results of a portion of this work, and the facts established were of very considerable practical importance, though the experiment itself was carried out under conditions more or less artificial.

Soil Chemistry and Bacteriology.

The work in this department included the study of the relation existing between the crop-producing power of certain soils and the extent of decay caused by them in solutions of peptone of known strength. It was found that some of the cylinder soils employed in the vegetation experiments showed consistent and uniform differences in this respect. The soils of series 1, 2, 3 and 4, differing materially from one another in their yield of nitrogen and of total dry matter, showed parallel differences in the amounts of ammonia set free by them from 10 per cent. solutions of Witte's peptone. It was found at the same time that the unequal power of these soils to cause decay in the solutions in question was determined by the numbers and the physiological efficiency of their bacteria, as well as by the chemical composition of the soils themselves. This fact has an important bearing on all soil inoculation problems, for it demonstrates forcibly that the bacterial activities in any soil, as expressed by the chemical reactions occurring in them, are but a function of the soil and its bacterial flora. Soil bacteria, producing desirable chemical changes in one soil,

will not necessarily produce the same changes, either quantitatively or qualitatively, when transferred to another soil. Hence the mere introduction of decay, or nitrifying bacteria into soils deficient in their power of decay and nitrification, can hardly be expected to yield satisfactory results unless the soils themselves are so modified as to offer a favorable medium for the development of these organisms.

The year's work also included further studies of the various members of the azotobacter group in pure and in mixed cultures. A number of facts thus gleaned add to our knowledge of the mechanism of nitrogen fixation and indicate that the first product of synthesis is a soluble protein substance, capable of diffusing through the cell wall. This fact, if substantiated by further study and proved to be such also in the case of P. radicicola, would help to explain the relation between leguminous crops and their tubercle bacteria to the great mass of soil organisms, and to succeeding non-leguminous crops.

These experiments, together with the analysis of the crops from the cylinder and box experiments of soil and manure samples, etc., have involved a large number of nitrogen determinations. The total number of such analyses was rather greater than 1,500. This department has also co-operated with the New York Experiment Station in studies on commercial cultures of P. radicicola, and, in co-operation with the Director, has prepared a critical study of the recent progress in soil bacteriology research, to be published in the report of the office of Experiment Stations for 1905.

Farm and Dairy.

The experiments carried out on the farm, while having the same object as heretofore, were considerably increased. It was possible during the last year to make a more complete study of the adaptability and usefulness for New Jersey conditions of many varieties of cow peas and soy beans, and to extend largely the study of the adaptability and suitability of alfalfa. Reports on alfalfa were received from a large number of growers, and the successful culture of the crops grown in many parts of the State is very encouraging, though much has yet to be learned as to methods of seeding and management. Detailed data in reference to growth and yield of forage crops and their use in the soiling systems are recorded in the report of the dairy husbandman.

Feeding experiments were also continued with dried beet pulp as a substitute for silage and with alfalfa hay as a substitute for protein

feeds. A feeding experiment with dried distillers' grains, a comparatively new product, was also carried out. The results obtained showed that the dried beet pulp possessed a high feeding value and that it was well adapted to substitute silage. It absorbs a large amount of water and serves admirably to furnish a succulent carbohydrate food for winter rations.

The results of the experiments with alfalfa hay confirmed those previously observed at this Station and elsewhere in showing its adapability as a substitute for the more expensive concentrated feeds.

The distillers' grains were used to substitute, as a source of protein, dried brewers' grains and cottonseed meal, and proved not only palatable and highly digestible but also a relatively cheap source of nitrogenous nutrients, and thus a valuable addition to the sources of supply of these protein feeds. Bulletins Nos. 189 and 190, embodying the results secured in the feeding experiments and in the growth of alfalfa, have been prepared by this department.

HORTICULTURE.

The work in this department has been enlarged by the appointment of George F. Warren, horticulturist, whose regular duties began July 1st. It is planned to make a careful study of the conditions now obtaining in the various fruit-growing sections, with a view to conducting experiments that shall determine whether a revival of the peach industry and the further development of apple growing in the State may not contribute to the material progress of those sections of the State which are peculiarly adapted for the culture of these crops. Attention will also be given to the asparagus industry, with a view to its development along right lines.

The experimental work at the Station, both in the field and in the plant-houses, has been continued. The season was favorable for asparagus, berries, small fruits, peaches and pears. The cherries and plums were injured and but few varieties of these were fruitful. The irrigation experiments were continued, and the prolonged drought, extending until August, made the artificial use of water extremely valuable, especially for blackberries. Asparagus was not benefited by irrigation, a result confirming previous experience.

BIOLOGY.

In this department the experimental study of oyster propagation has been continued; the work of the past season having been particularly devoted to the problems of spat fixation.

The scope of these investigations was considerably extended by instituting a comparative study of localities; identical experiments with similar apparatus being conducted at three or four separate Stations on our bays, viz., two at Tuckerton, one at Barnegat and one at Keyport.

The season has been fairly favorable so far as natural conditions were concerned, and the time from mid-May until September was almost continuously occupied with the details of the maintenance of these Stations. A series of rearing boxes, specially devised for retaining the minute oyster fry and at the same time furnishing conditions favorable to the development of oyster food, was installed at each Station. Unusual tides, storms and other agencies, however, caused serious interference with the continuity of the experiments and called for frequent repairs.

The natural set of spat was best seen at Barnegat, and a study of this phase of the problem proved so profitable that it is the intention of the Biologist to make this place his chief Station for the immediate future.

A histological study of the ripening of the sexual cells of our species of oyster was also begun.

An experiment to ascertain the effect of the presence and the absence of the male fowl on egg production of poultry was also begun, and the results obtained recorded. It is hoped to increase the scope of these experiments under the continued superintendence of Mr. George A. Billings, who has furnished the record for the past year.

BOTANY.

In the Botanical Department the work of the past year has been largely in continuation of lines of experiments in plant breeding laid down during previous years. With sweet corn this has consisted of the development of the cross of "Black Mexican" with the "Country Gentleman," from which four branches in this breeding are now projected. Upon two plots the "Malakhov" has been bred upon the "Crosby" and the "Premo," respectively, for the purpose of developing

greater earliness in a truly sweet corn. Four other crosses of sweet corn have been continued through their second generation upon the gardens, and forty elsewhere throughout the State through the co-operation of as many growers of truck crops.

The addition of nearly an acre to the home grounds in long narrow strips through a large field permitted of the isolated growth of a large block of "Stowell's Evergreen" sweet corn for the United States Department of Agriculture and for further testing and crossing of sweet corn.

A block of the new land was given to a test of samples of the "Voorhees" sweet corn from widely-separated States of the Union, including the Hawaiian islands.

A new feature of the year was the growing of quite a full set of popcorns from various parts of the world, including Brazil, Chili and India, with a view to a classification of this group of corns, and breeding with the hope of improving the yield and other qualities.

A tenth of an acre was devoted to thirty-three crosses of summer squashes, and a nearly equal area to the breeding of the winter species. For the first time Japanese varieties have been added to the list of squashes, and several crosses with these have been obtained.

Considerable space was given to a full list of the commercial list of eggplants, including the "Jersey Belle" and some of the later combinations made by the department. A hybrid between the "Scarlet Chinese" and our ordinary sorts has fruited the present season, and many new crosses have doubtless been obtained with this and other varieties.

Over a hundred crossed tomatoes have been grown, and among them are several of promise to both the trucker and the grower of fancy fruit. A block of plants of a superior cross between "Magnus" and "Ponderosa" has furnished a good supply of seed for distribution under the name of "Magnerosa." A fresh supply of seed of the "Station Yellow" has likewise been secured. Substantial progress has been made toward a more desirable and uniform shape in commercial tomatoes, as also in the reduction of the seediness of this class of vegetable fruits.

Increased attention has been given to the development of better wax, green pod and lima beans, and results are at hand that show much encouragement. In other words, an early prolific sort, with large round pods, having thick, tender, stringless flesh, and small white seeds, is reasonably hoped for by combining the breeding of the best sorts with

rigid selection. An interesting hybrid has been secured between several bush beans and the "Scarlet Runner," all of which are of the pole type and give a new color of bloom-making; possibly an ornamental climber combined with a fair yield of green pods for the table.

The experiments with hybrid salsify have added some facts as to the selecting of seed that may be of service with other plants that are under breeding tests.

A bulletin upon seed distribution resulted in the receipt of a large number of requests, in response to which 872 packets were sent out. A postal-reply file shows that in many instances these novelties from the department have been cared for with much interest. This wholesale testing in the most practical way is of much service to the Experiment Station.

Some time has been spent in the daily routine of the office, suggesting treatment for diseases, weeds, etc. It is a pleasure to record increased attention shown the department by the seedsmen of the country.

ENTOMOLOGY.

The work of the year has been along three distinct lines—*first*, the regular work of the Experiment Station; *second*, the special work of the mosquito investigation; *third*, the work of the State entomologist.

In the Experiment Station the main line of work has been the development of petroleum oils, so treated as to be readily soluble, or, at least, miscible in water, so as to be effectively used as an insecticide, especially against the San José or pernicious scale. A very large number of preparations were tested, and it is believed that success has been attained. The experiments made proved remarkably successful, and further developed the point that the wrong time of the season had been heretofore selected to apply sprays as against the scale. Bulletin No. 186 presents the results in brief, and details are given in this report.

A series of observations was made to determine the temperature at which insect eggs develop under water, and just what use could be made of water in controlling those species most injurious on the cranberry bogs. The results obtained suggest better methods of practice in managing the water-supply for the best interests of the bogs.

The increase of gypsy and brown-tail moths in Massachusetts, great

enough to induce that State to appropriate $300,000 for their control, and the suggestion that the insects threatened New Jersey, made it desirable to visit the infested areas to determine, first of all, whether danger existed, and if so, what could be done to ward it off. The results are presented in this report.

Shade trees received considerable attention, and Bulletin No. 181, dealing with the species most commonly infesting them and ornamentals, is the outcome of the study. That the work was timely is proved by the demand for the bulletin. The occurrence of the oystershell bark-louse in Southern New Jersey, and of the cottony maple scale in the East Central section, led to special studies of both these species. Numerous minor investigations were made, among them the methods of dealing with onion maggots and the habits of the cornstalk borer.

The mosquito work has proceeded in somewhat different lines from those of the previous years. There has been less necessity for studying life histories and more attention has been paid to the practical locating of breeding places and to assisting such communities as were ready to do work on their own behalf. One community only—the city of Elizabeth—became entitled to State aid, and the sum of $500 was paid to the treasurer, on presentation of the proof demanded by law. Dr. John B. Smith was appointed an executive officer in general charge of the work, and as his assistants, Mr. H. H. Brehme and Mr. John A. Grossbeck. Mr. W. P. Seal was especially engaged to arrange for the introduction of top minnows (*Gambusia affinis*) into likely places in New Jersey, an experiment that has not yet been completed. Among the more important work done is a thorough survey of the breeding marshes to determine the probable cost of completely ridding the State of the salt marsh species. It is found that $350,000 will be required.

The work done by the State Entomologist is reported to the State Board of Agriculture, although carried on in connection with the work of the Station.

REPORT OF THE CHEMISTS.

REPORT OF THE CHEMISTS.

FERTILIZERS.

ANALYSES OF FERTILIZER SUPPLIES, HOME MIXTURES AND SPECIAL COMPOUNDS.

ANALYSES AND VALUATIONS OF COMMERCIAL FERTILIZERS AND GROUND BONE.

1. *Introduction.*
2. *The trade values of fertilizing ingredients for 1905, and the examination of the standard materials supplying them.*
3. *The examination and valuation of home mixtures and special compounds.*
4. *The examination and valuation of manufactured brands and sundry materials.*

1.

INTRODUCTION.

The method of inspection this year was the same as in the two previous years. Mr. L. H. Williamson, the official sampler of the Station, collected practically all of the samples; a few were sent in by granges or individuals. The inspection has been thorough, and twenty of the twenty-one counties of the State were visited, and 858 samples obtained from 241 different dealers. From among the duplicates of each brand, a selection for analysis was made, with the aim that the samples of any one firm should be taken, as far as possible,

from different portions of the State, and should represent large stocks of the different brands. In twenty-two cases where the analysis was widely divergent from the guarantee a second, and in a few cases a third, sample was selected for analysis, and the results of all such analyses appear together in the tables.

The inspection this year has required the following analyses:

380	Samples of Complete Commercial Mixtures.
25	" " " " " (duplicates).
28	" " Ground Bone.
104	" " Fertilizing Raw Materials.
11	" " Home Mixtures.
20	" " Specially Compounded Mixtures.
29	" " Sundry Materials.
597	

The analysis of these samples required about five thousand five hundred separate determinations.

The following is a list of those business houses the analyses of whose goods are published in this report.

Manufacturers

WHOSE GOODS HAVE BEEN SAMPLED AND ANALYSED THIS YEAR.

J. H. Allen & Son....Lawrence Station, N. J.
American Agricultural Chemical Co....26 Broadway, New York City.
Bradley Branch....92 State St., Boston, Mass.
Chemical Co. of Canton Branch....32 S. Charles St., Baltimore, Md.
Chicopee Guano Branch....88 Wall St., New York City.
Clark's Cove Branch....81 Fulton St., New York City.
Crocker Branch....56 Pearl St., Buffalo, N. Y.
East India Branch....93 William St., New York City.
Great Eastern Branch....Rutland, Vt.
Milsom Branch....963 William St., E. Buffalo, N. Y.
Pacific Guano Branch....27 William St., New York City.
Packers' Union Branch....150 Nassau St., New York City.
Moro Phillips Branch....710 Bourse, Philadelphia, Pa.
Preston Branch....Greenpoint, L. I., N. Y.
Quinnipiac Branch....83 Fulton St., New York City.
Read Branch....16 Exchange Place, New York City.
Reese Branch....Baltimore, Md.
Sharpless & Carpenter Branch....710 Bourse, Philadelphia, Pa.
Susquehanna Branch....Baltimore, Md.
Tygert-Allen Branch....2 Chestnut St., Philadelphia, Pa.
Wheeler Branch....Rutland, Vt.
Williams & Clark Branch....27 Williams St., New York City.

Armour Fertilizer Works.................................Baltimore, Md.
Warren Atkinson.................................Mullica Hill, N. J.
J. H. Baird.................................Marlboro, N. J.
J. A. Ballenger.................................Mullica Hill, N. J.
Baugh & Sons Co....................20 S. Delaware Ave., Philadelphia, Pa.
The Berg Co....................Russel and Bath Sts., Philadelphia, Pa.
Bonora Chemical Co.................................Kearny, N. J.
Bowker Fertilizer Co....................43 Chatham St., Boston, Mass.
Bradley & Green Fertilizer Co., Ninth St. and Girard Ave., Philadelphia, Pa.
Wm. M. Brown.................................Cedarville, N. J.
E. Frank Coe Co....................133 Front St., New York City.
Jos. Camp.................................Pierces, N. J.
C. C. Clark & Son.................................Mt. Ephraim, N. J.
John S. Collins & Son.................................Moorestown, N. J.
Collins & Pancoast.................................Merchantville, N. J.
A. A. Cortelyou.................................Neshanic, N. J.
S. V. Davis.................................Shiloh, N. J.
B. F. Demaris & Son.................................Cedarville, N. J.
Denise & Denise.................................Freehold, N. J.
E. Dougherty.................................Philadelphia, Pa.
H. W. Doughten.................................East Moorestown, N. J.
Eagle Guano Co.................................New York City
James Ewing.................................Cold Spring, N. J.
J. C. Fifield & Sons Co.................................Bakersville, N. J.
Fithian & Pennell.................................Bridgeton, N. J.
J. C. Griscom.................................Woodbury, N. J.
Hendrickson & Dilatush.................................Robbinsville, N. J.
S. M. Hess & Bro....................Fourth and Chestnut Sts., Philadelphia, Pa.
Jacob V. Higgins.................................Flemington, N. J.
Ira Hill.................................Copper Hill, N. J.
Hill & Co.................................Flemington, N. J.
Hires & Co.................................Quinton, N. J.
Barton Hoffman.................................Ringoes, N. J.
P. Hoffman & Bro.................................Raubsville, Pa.
The Hubbard Fertilizer Co.................................Baltimore, Md.
International Seed Co.................................Rochester, N. Y.
Keystone Chemical Fertilizer Co....................3 S. Front St., Philadelphia, Pa.
Hervey Kuhl.................................Flemington, N. J.
Lambertson & Hance.................................Freehold, N. J.
Samuel Lederer & Sons.................................New Brunswick, N. J.
C. A. Lippincott & Bro.................................Moorestown, N. J.
Joseph Lister.................................Chicago, Ill.
Lister's Agricultural Chemical Works.................................Newark, N. J.
The Mapes F. and P. Guano Co....................143 Liberty St., New York City.
Michigan Carbon Works.................................Detroit, Mich.
John E. Minch.................................Bridgeton, N. J.
Minch Bros.................................Bridgeton, N. J.
Monmouth Fertilizer Works.................................Shrewsbury, N. J.
E. Mortimer & Co.................................New York City.
J. R. Moore.................................Swedesboro, N. J.
L. Moritz....................1321 North Fifth St., Philadelphia, Pa.

Muzzy Bros..Paterson, N. J.
Nassau Fertilizer Co..........................5 Beaver St., New York City.
New England Gas and Coke Co...............................Boston, Mass.
Albert Nelson & Co...Allentown, N. J.
James E. Otis..Tuckerton, N. J.
S. L. Pancoast...Mullica Hill, N. J.
Peterson & Smith...Woodstown, N. J.
John Repp..Glassboro, N.J.
Edward Rigg, Jr..Burlington, N. J.
M. F. Riley..Elmer, N. J.
C. W. Saul...Rio Grande, N. J.
Scott Fertilizer Co..Elkton, Md.
Sharpless & Bro..Camden, N. J.
J. E. Sherman..Frenchtown, N. J.
M. L. Shoemaker & Co.....Delaware Ave. and Venango St., Philadelphia, Pa.
Lester Shurts..Neshanic Station, N. J.
Jos. Smith & Co..Stockton, N. J.
R. W. Smith..Elmer, N. J.
G. F. Taylor & Co..New York City.
Taylor Bros..Camden, N. J.
The Taylor Provision Co....................................Trenton, N. J.
I. P. Thomas & Son Co................2 S. Delaware Ave., Philadelphia, Pa.
Trenton Bone Fertilizer Co.................................Trenton, N. J.
F. W. Tunnell & Co...................15 N. Fifth St., Philadelphia, Pa.
The J. E. Tygert Co.................28 S. Delaware Ave., Philadelphia, Pa.
Vineland Grain Co..Vineland, N. J.
A. J. Vreeland...Matawan, N. J.
Emil Wahl Mfg. Co..Philadelphia, Pa.
George M. Wells..Moorestown, N. J.
J. Wenderoth & Sons..Camden, N. J.
West Jersey Marl and Transportation Co.....................Woodbury, N. J.
W. E. Whann..William Penn, Pa.
John Whann & Son...Philadelphia, Pa.
Winterbottom, Carter & Co..................................Egg Harbor City, N. J.
Woodward & Dickerson.......................................Philadelphia, Pa.

The wholesale prices of crude products or raw materials are quoted every Monday in the well-known trade journal, "The Oil, Paint and Drug Reporter." These prices have been tabulated for the entire year, and have then been recalculated, in order to express them as prices per pound of actual plant-food, which is the form adopted by the Experiment Stations of this country. The recalculation has been made upon the basis of the following analyses:

Nitrate of Soda...........................	16	per cent. Nitrogen.
Sulphate of Ammonia......................	20½	" "
Dried Blood	12½	" "
Acid Phosphate	12	" { Available Phosphoric Acid.
High-Grade Sulphate of Potash.............	50	" Potash.
Double Sulphate of Potash and Magnesia.....	25	" "
Muriate of Potash.........................	50	" "
Kainit	12½	" "

On account of the fact that the report of the Experiment Station is made upon October 30th of each year, the results which appear in tabular form are for the year 1904. During that year the prices of the nitrogen-furnishing materials fluctuated somewhat, becoming stronger toward the close of the year. As it is probably at this time that the manufacturers of mixed goods place their contracts for raw materials, the quotations for the last four months of 1904 and the first two months of 1905 have been averaged as a more suitable basis for the determination of the schedule of valuations for 1905.

WHOLESALE COST, PER POUND, IN NEW YORK.

MONTHS. 1904.	OF NITROGEN IN FORM OF—						OF PHOSPHORIC ACID IN FORM OF—		OF POTASH IN FORM OF—							
	Nitrate of Soda.		Sulphate of Ammonia.		Dried Blood.		Acid Phosphate.		Kainit.		Muriate of Potash.		Double Sulphate of Potash and Magnesia.		High-Grade Sulphate of Potash.	
	Max	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.
January	13.8	13.6	15.8	15.7	15.3	15.1	3.4	3.0	3.8	3.6	3.8	3.8	4.6	4.5	4.3	4.2
February	13.5	13.5	15.7	15.6	15.5	15.3	3.4	3.0	3.7	3.5	3.8	3.8	4.5	4.4	4.2	4.2
March	13.9	13.7	15.7	15.6	15.5	15.3	3.4	3.0	3.8	3.6	3.8	3.8	4.6	4.5	4.3	4.2
April	15.1	15.0	15.5	15.4	15.8	15.5	3.4	3.0	3.8	3.6	3.8	3.8	4.6	4.5	4.3	4.2
May	14.6	14.5	15.3	15.1	15.7	15.4	3.4	3.0	3.8	3.6	3.8	3.8	4.6	4.5	4.3	4.2
June	13.8	13.8	15.0	14.9	15.5	15.2	3.4	3.0	3.8	3.6	3.8	3.8	4.6	4.5	4.3	4.2
July	14.0	13.6	14.9	14.8	15.5	15.2	3.4	3.0	3.8	3.6	3.8	3.8	4.6	4.5	4.3	4.2
August	13.5	13.5	14.6	14.5	15.5	15.2	3.4	3.0	3.8	3.6	3.8	3.8	4.6	4.5	4.3	4.2
September	13.8	13.8	14.7	14.6	15.5	15.2	3.4	3.0	3.8	3.6	3.8	3.8	4.6	4.5	4.3	4.2
October	14.1	13.9	14.8	14.8	15.9	15.6	3.4	3.0	3.8	3.6	3.8	3.8	4.6	4.5	4.3	4.2
November	14.5	14.5	15.1	15.1	16.1	15.8	3.4	3.0	3.8	3.6	3.8	3.8	4.6	4.5	4.3	4.2
December	14.8	14.8	15.5	15.5	16.1	15.8	3.4	3.0	3.8	3.6	3.8	3.8	4.6	4.5	4.3	4.2
Average, for 1904	14.1		15.2		15.5		3.2		3.7		3.8		4.5		4.2	
Average, for 1903	13.2		15.2		15.8		3.2		3.7		3.8		4.5		4.3	
Average, for 1902	13.0		14.6		14.4		3.1		3.6		3.7		4.5		4.2	

2.

THE TRADE VALUES OF FERTILIZING INGREDIENTS FOR 1905.

The estimated commercial value of fertilizers is separate and distinct from the agricultural value. The latter depends upon the character and form of the materials with reference to their availability and the needs and value of the crop for which they are to be applied. The former, on the other hand, is determined by market and trade conditions, such as supply and demand, the cost of production, etc., and is derived by applying to the various forms of plant-food ingredients, as shown by analysis, the values previously determined upon for them. These values are fixed from year to year and are altered according to the cost of the standard materials containing them, as shown in market reports and actual transactions.

The wholesale prices per pound of plant-food prevailing in New York during the six months immediately preceding March 1st last were, for nitrogen in nitrate of soda, 14.4 cents; in sulphate of ammonia, 15.3 cents, and in high-grade dried blood, 15.8 cents; for available phosphoric acid in acid phosphate, 3.2 cents, and for actual potash in muriate of potash, 3.7 cents; in kainit, 3.7 cents; in double sulphate of potash and magnesia, 4.5 cents, and in high-grade sulphate of potash, 4.3 cents. A comparison of these figures with those of last year will show that the high prices of all forms of nitrogen still maintain, nitrate of soda showing an advance of 0.7 cents, or 2.2 cents higher than in 1903; the prices of acid phosphate and the potash salts show little change.

From these wholesale prices as a basis, the following schedule of trade values was arranged at a meeting of Station directors and chemists for use in Connecticut, Massachusetts, Rhode Island, Vermont and New Jersey during the season of 1905:

Schedule of Trade Values Adopted by Experiment Stations for 1905.

	Cents per pound.
Nitrogen in Nitrates	17.0
" " Ammonia Salts	17.5
Organic Nitrogen in dried and fine-ground fish, meat and blood, and in mixed fertilizers	18.5
" " " fine-ground bone and tankage	18.0
" " " coarse bone and tankage	13.0
Phosphoric acid, soluble in water	4.5
" " " " ammonium citrate*	4.5
" " insoluble in fine bone and tankage	4.0
" " " " coarse bone and tankage	3.0
" " " " mixed fertilizers	2.0
" " " " fine-ground fish, cottonseed meal, castor pomace and wood ashes	4.0
Potash as Muriate	4.25
" " Sulphate, and in forms free from muriates (or chlorids),	5.0

The Examination of Unmixed Fertilizing Materials.

The results of the analyses of 104 samples of standard unmixed raw materials appear in tabulated form upon subsequent pages. With a few exceptions the analyses indicate that the materials were of good quality, although the usual wide variations are shown in the case of dried fish and tankage.

The samples of nitrate of soda, Nos. 5395, 5497 and 5692, were of inferior quality; they were found to contain 4.77, 5.96 and 2.45 per cent. of actual potash, respectively, accompanied by from 4.01 to 5.23 per cent. of chlorin. Whether the presence of the potash in these samples was due to adulteration, accidental admixture or an inferior grade of goods, it is difficult to determine. If the latter case the chlorin is probably due to the common salt (sodium chlorid) present, and the potash is probably in the form of nitrate of potash, or possibly partially as per-chlorate. It is claimed, however, by the nitrate producers of Chile that no such low-grade nitrate is shipped, and that the export of such material as the above samples would be prohibited by the penalties which are inflicted at the time of sale. It seems very possible, therefore, that an admixture of foreign material occurred in these samples after reaching this country, although the absence of

* The solubility of phosphates, in ammonium citrate solutions, varies with the degree of heat. An act of the Legislature (see Laws of New Jersey, 1874, page 90) provides that in this determination the temperature used shall not exceed 100° Fahr.; in other States 150° Fahr. has been adopted. Consequently the Station valuation of phosphoric acid soluble in ammonium citrate has been fixed at *four cents* per pound for Connecticut, Massachusetts, New York, Rhode Island and Vermont, and at *four and one-half cents* per pound for New Jersey.

definite data as to whether or not these samples were taken from original bags makes it impossible for the Station to fix the responsibility for their inferior grade. At any rate, in these samples, except in the case of No. 5497, where the purchaser was able to secure a low ton price by ordering far ahead, the consumer paid a proportionately high price for his nitrogen, even allowing five cents per pound for the potash present. In No. 5395 the nitrogen cost 17.40 cents per pound, and in No. 5692 18.73 cents per pound, the average cost of the nitrogen in the other eleven samples being 16.06 cents per pound. The remaining samples varied from 15.26 to 15.90 per cent. nitrogen, or 93 to 96 per cent. nitrate of soda. The single sample of nitrate of potash analysed was of good quality and was the cheapest source of nitrogen examined this year.

Three samples of dried blood, Nos. 5030, 5035 and 5039, contained abnormal quantities of phosphoric acid. By correspondence with the manufacturer it was ascertained that in the purchase of these lots blood containing 14 per cent. ammonia was desired by the purchasers, and as immediate shipment was required, and the manufacturer had in stock only blood of 17 per cent. quality, sufficient undissolved bone black was added to reduce the ammonia to the desired figure. Such an addition would, of course, in no way affect the quality of the blood, and if the materials were purchased and paid for on the basis of 14 per cent. ammonia, no injustice was done the consumer.

The samples of dried fish showed the usual wide variations, ranging from 3.53 to 9.55 per cent. nitrogen and 0.91 to 7.82 per cent. phosphoric acid. Three of these samples were sold as crude fish and at much lower prices, but in two of them, Nos. 5433 and 5565, the nitrogen was obtained at a much higher cost per pound than in any of the other samples. The samples of tankage also showed the usual wide variations in composition, depending largely upon the amount of bone present. They also varied widely in mechanical condition. The requirement of a guarantee is particularly important in materials of this nature.

All but one of the acid phosphates examined were of standard quality. Samples Nos. 5638, 5676, 5205 and 5682, although sold as soluble bone phosphate or acidulated bone, are included with the plain superphosphates, where their analyses show that they belong. One sample of muriate of potash, No. 5375, was of inferior quality; a duplicate sample, claiming to represent the same shipment, No. 5850, was shown to be of average quality.

Since the samples represent goods actually on the market at the prices given, the average cost per pound of their several ingredients may be fairly assumed to represent the average prices charged for nitrogen, phosphoric acid and potash by different manufacturers. These average prices are 16.1 cents per pound for nitrogen in nitrate of soda, 15.2 cents in sulphate of ammonia, 11.7 cents in nitrate of potash, 17.9 cents in dried blood, 20.1 cents in dried fish, and 16.9 cents in tankage; 3.54 cents per pound for available phosphoric acid in acid phosphate, and 4.2, 4.4 and 4.2 cents per ound for actual potash in muriate of potash, sulphate of potash and kainit, respectively. The raw materials, on the average, therefore, furnished the fertilizing ingredients at somewhat lower prices than the Station's valuations, with the exception of dried fish, which, in most cases, was an expensive form of nitrogen this year. It must be said, however, that the greater number of the samples of fish represented sales through dealers, and were sold in the same way as complete fertilizers.

3.

THE EXAMINATION OF HOME MIXTURES AND SPECIAL COMPOUNDS.

The analyses of eleven home mixtures and twenty special mixtures are published herewith. In most of the latter merely the guaranteed analysis, which is given in the tables, was required of the manufacturer; in others the use of certain ingredients was insisted upon. Nearly all of these samples were sent in by the farmers or granges using them, and are not to be considered as official samples. The ingredients of the home mixtures and special mixtures reported to us were as follows:

Composition.

Home Mixtures.

No. 5858.

800 lbs. Dried Blood.
200 " Tankage.
1,400 " Acid Phosphate.
100 " Muriate of Potash.

No. 5770.

75 lbs. Nitrate of Soda.
2,000 " Ground Bone.
300 " Muriate of Potash.

No. 5769.

200 lbs. Nitrate of Soda.
100 " Sulphate of Ammonia.
100 " Dried Blood.
500 " Steamed Bone.
700 " Acid Phosphate.
400 " Sulphate of Potash.

No. 5159.

2,000 lbs. Chicken and Pigeon Manure.
100 " Nitrate of Soda.
500 " Acid Phosphate.
150 " Muriate of Potash.

No. 5158.

2,000 lbs. Wool Waste.
300 " Acid Phosphate.
50 " Nitrate of Soda.
100 " Muriate of Potash.

No. 5814.

100 lbs. Nitrate of Soda.
200 " Dried Blood.
200 " Dried Fish.
250 " Tankage.
450 " Dissolved Bone.
400 " Acid Phosphate.
400 " Muriate of Potash.

No. 5815.

50 lbs. Nitrate of Soda.
100 " Dried Blood.
100 " Dried Fish.
300 " Tankage.
450 " Dissolved Bone.
700 " Acid Phosphate.
300 " Muriate of Potash.

No. 5396.

2,000 lbs. Ground Bone.
200 " Acid Phosphate.
2,000 " Kainit.
300 " Muriate of Potash.

No. 5046.

... lbs. Wool Waste.
... " Acid Phosphate.

No. 5494.

275 lbs. Nitrate of Soda.
275 " Tankage.
275 " Dried Fish.
900 " Acid Phosphate.
275 " Muriate of Potash.

No. 5458.

200 lbs. Nitrate of Soda.
100 " Sulphate of Ammonia.
100 " Dried Blood.
500 " Steamed Bone.
800 " Acid Phosphate.
400 " Muriate of Potash.

Special Compounds.

No. 5065.

100 lbs. Nitrate of Soda.
300 " Bone Tankage.

No. 5848.

495 lbs. Nitrate of Soda.
300 " Tankage.

4.

THE EXAMINATION AND VALUATION OF MANUFACTURED BRANDS AND SUNDRY MATERIALS.

1. Complete Fertilizers.

The number of samples of complete fertilizers analysed this year was 380, which is somewhat less than last year; in addition to these twenty-five duplicate samples were analysed for reasons previously stated. These 380 brands are the product of ninety-six establishments, if the branches of the American Agricultural Chemical Company be considered separately, the number being eight less than last year and five less than in 1903. The average number of brands per manufacturer this year is four, a slight decrease over previous years. There are sixty-nine manufacturers, each represented by four or less, eighteen by from five to eight, five by from nine to twelve, and four from fourteen to twenty-six brands. Certain manufacturers still multiply their brands to what should seem to be an excess of that needed for a range of choice, especially as in many cases the differences are in name only. Sixty-seven per cent. of the brands analysed are put on the market by eighty-seven manufacturers, each supplying from one to eight brands; the remaining 33 per cent. of the brands are supplied by nine manufacturers, with from nine to twenty-six brands apiece. It is difficult to understand why the trade requirements should be more exacting for these nine manufacturers than the other eighty-seven.

The same apparently wide difference of opinion among manufacturers as to to the requirements of special crops is quite as noticeable as in previous years. This year there are 115 different brands designated for potatoes, with fifty-eight different guarantees; forty-five brands for truck, with thirty-five guarantees; twenty-seven for corn, with twenty-three guarantees; seventeen for sweet potatoes, with twelve guarantees. The guarantees in brands for potatoes vary from 1 to 5, 4 to 10, and 1 to 10 per cent. of nitrogen, available phosphoric acid and potash, respectively; for truck from 1½ to 10, 4½ to 10, and 1 to 10 per cent., respectively; for corn from 1 to 4, 5 to 10, and 1 to 7 per cent., respectively; and for sweet potatoes, from 1¼ to 3, 5 to 8, and 2 to 10 per cent., respectively. These wide

variations in guarantee of brands designated for use on the same crop emphasize very strongly how little reliable information is supplied by the name of a brand as regards its use for any special crop.

Guarantees and Actual Composition.

Every brand examined this year was accompanied by a guarantee as required by law. One hundred and forty samples, however, were defective in respect to phosphoric acid, either available or total phosphoric acid alone being guaranteed.

A comparison of the analyses of each brand, with its accompanying guarantee, shows that 46 per cent. are deficient in one or more of the plant-food elements. The deficiencies, compared with those of the past nine years, are shown in the following tabulation, in which deficiencies in nitrogen of 0.20 per cent., and in phosphoric acid and potash of 0.30 per cent., have been ignored.

YEAR.	NUMBER OF BRANDS.				Deficiencies possible.	ACTUAL DEFICIENCIES.			
	Examined.	Found as guaranteed.	Found deficient.	Percentage deficient.		Nitrogen.	Phosphoric Acid	Potash.	Percentage.
1896	329	211	118	36	987	30	52	56	14.0
1897	234	194	90	32	852	29	47	30	12.4
1898	303	201	102	34	909	43	29	49	13.3
1899	321	222	99	31	963	33	51	32	12.0
1900	298	214	84	29	894	33	35	31	11.1
1901	308	202	106	35	924	31	60	34	13.5
1902	391	269	122	31	1,173	44	54	49	12.5
1903	390	246	144	37	1,170	83	47	52	15.6
1904	434	295	139	32	1,302	79	39	45	12.6
1905	380	207	173	46	1,140	100	62	34	17.2

As indicated in the table, there are 196 deficiencies distributed among 173 brands, nineteen being deficient in two, and two brands in all three ingredients. As there is a total of 1,140 deficiencies possible in the 380 brands examined, it follows that 17.2 per cent. of these possibilities have actually occurred, a much higher figure than observed in any of our past ten inspections. This percentage would be still larger, however, were it not for the allowance of 0.20 and 0.30

per cent. referred to, whereby many brands would be classed as deficient besides those stated above. On the other hand, certain brands, by their analyses, give evidence of poor mixing rather than of intentional inferiority. An examination of the tables of analyses shows that in seventy-eight brands classed as deficient in one or more ingredients, the deficiency is balanced by an excess in one or both of the other ingredients; ninety-six brands, or 25 per cent., however, remain which are deficient in the total plant-food guaranteed. As will be observed, the deficiencies in nitrogen are greater than those in phosphoric acid and potash together. This has been practically true for the past three years, and is probably explained by the fact that all nitrogenous raw materials since 1902 have shown a marked and upward tendency in price. This has doubtless led many manufacturers to mix more closely than in previous years, and not make sufficient allowance for possible inequalities in mixing. The variability in composition of nitrogenous materials, particularly tankage, fish and other organic forms, also has probably had an influence in the poor standing of the manufactured brands as regards their nitrogen guarantee, especially in the case of those manufacturers who do not exercise a strict chemical control over their output. A slight deficiency in one element and a corresponding excess in another, as a rule, works no hardship on the consumer, assuming he gains an equivalent fertility value; but in those brands, and there are several such this year, where a deficiency in one element is made up by a very large excess in another, the consumer receives a fertilizer of an entirely different formula than that which he expected, and which may be quite unsuited for his needs. For instance, if a fertilizer guaranteed 2 ammonia, 8 available and 10 potash, is found to analyse 2 ammonia, 9 available and 9½ potash, no particular injury has been done the purchaser, as he receives a commercial equivalent of the plant-food guaranteed, with only a trifling change in the ratio of the different ingredients. If, on the other hand, a fertilizer bearing the above guarantee should analyse 4 ammonia, 6 available and 6 potash, the purchaser would have good reasons for complaint, for although he has received a commercial equivalent of plant-food, it is in entirely different balance from that indicated by the guarantee. Instead of a ratio of 1-4-5, he would be receiving a ratio of 1-1½-1½.

As has been stated many times before, in a number of brands the guarantee is not a safe guide as to the composition and value of the fertilizer. Certain manufacturers, either through ignorance or care-

lessness, or for advertising purposes, put into their brands an amount of plant-food quite at variance with that claimed by their guarantee. Where these amounts are in excess of the guarantee the purchaser does not suffer a financial loss, yet there is no warrant for assuming that such an excess would be supplied at another time, as the manufacturer is only responsible for his minimum guarantee.

For various reasons, this year the Station was led to make duplicate analyses of certain brands which varied widely from their guarantees. Nineteen brands were analysed in duplicate and three in triplicate. Twelve of these brands, while showing considerable variation in the amounts of the different ingredients present, agreed substantially in the form of those ingredients. In the other ten brands, however, while the total nitrogen, total phosphoric acid and potash, as a rule, agreed fairly well, the form in which the nitrogen existed showed great variations. In four of these brands one sample contained nitric and organic nitrogen, the duplicate only organic; in two brands one sample contained the three forms of nitrogen, while the duplicate contained no nitrates; in two brands one sample contained the three forms of nitrogen, while the duplicate contained none from ammoniacal salts; and in two brands the nitrogen in one sample existed as nitric and organic, while in the duplicate it existed as ammonia and organic nitrogen. These facts indicate that manufacturers are not always careful to maintain the same formula in mixing up different lots of the same brand; or, in other words, in many cases a brand name does not indicate the use of a certain formula. There may be good trade reasons for this practice, but from the standpoint of the consumer it is to be deplored. Many intelligent users of fertilizers plan to supply their crops with a certain amount of soluble, readily available nitrogen, and select brands which promise to contain nitrogen in that form. If they are supplied, however, with a brand which contains no soluble nitrogen, not only are they purchasing a fertilizer different from what they intended, but it may be entirely unsuited for their uses, and may cause a partial or complete failure of their crop. It should be stated, further, that the brands showing these variations are all the product of large manufacturers, where it would seem that uniformity in mixing should be possible, and where a strict chemical control of these mixtures should be in operation. A few of the duplicate analyses were made in samples which represented comparatively small quantities. The Station always seeks to secure more representative samples, and these were taken only because no others could be found.

Station's Valuations and Selling Prices.

The Station's valuation per ton is derived by applying to the different constitutents the schedule of prices already given. It is intended to show the retail cash cost of the amount of nitrogen, phosphoric acid and potash contained in one ton if they were bought at factory in the form of unmixed raw materials. The difference between the selling price and Station's value shows, therefore, the charge that is made for mixing, bagging, shipping and *selling* the several brands.

The Station believes that the prices at factory furnish the fairest basis for a comparison of the charges made by the different manufacturers for the various brands. The difficulty in securing such information is very evident, and the Station, therefore, publishes only the prices charged by the dealers whose goods the samples represented. These prices differ in various parts of the State, due mainly to differences in freight rates, the amount sold, method of purchase and commission charged. With some brands these variations are very great, amounting in certain cases to as much as $10 per ton.

The average composition, commercial valuation and selling price of all of the brands of complete fertilizers examined each year for the past ten years, together with the actual and the percentage difference by which the selling price exceeds the valuation, are shown in the following tabulation:

YEAR.	Total Nitrogen.	Total Phos. Acid.	Available Phos. Acid.	*Insoluble* Phos. Acid.	Potash.	*Station's* valuation.	Selling price.	Actual difference.	Percentage difference.
	%	%	%	%	%				%
1896	2.51	10.86	8.21	2.65	5.02	$21 70	$30 33	$8 63	39.8
1897	2.54	10.93	8.01	2.91	5.01	21 58	29 28	7 70	35.7
1898	2.45	10.69	8.37	2.32	5.38	19 90	28 58	8 68	43.6
1899	2.41	10.58	8.27	2.31	5.67	19 95	27 75	7 80	39.1
1900	2.30	11.03	8.44	2.59	5.89	20 77	27 26	6 49	31.2
1901	2.31	10.48	8.08	2.40	5.77	21 19	27 31	6 12	28.9
1902	2.38	10.47	8.09	2.38	5.32	21 32	27 66	6 34	29.7
1903	2.27	10.52	8.15	2.37	5.49	20 50	27 57	7 07	34.5
1904	2.30	10.19	8.13	2.06	5.71	20 91	27 63	6 72	32.1
1905	23.8	9.87	7.84	2.03	5.97	21 51	28 27	6 76	31.4

The average composition of the complete fertilizers this year differs a little from that of late years. The amount of total nitrogen is somewhat higher, but there is a marked decrease in total and available phosphoric acid, the insoluble being about the same as last year, but much lower than in previous years. On the other hand, potash shows an increase over last year of 0.26 per cent., and nearly one-half of 1 per cent. over 1903, decidedly the highest average shown in any of the Station's inspections. The quality of the goods was generally excellent; the tendency noted in previous years towards an increased use of the water-soluble forms of nitrogen is again marked this year. In 246 brands nitrogen was found in the form of nitrates, and in 115 brands in the form of ammonia salts, while in sixty-nine brands both of these soluble forms of nitrogen were found in quantities exceeding 0.20 per cent. Ninety-two hundredths of 1 per cent., or nearly 39 per cent. of the total nitrogen, was in the water-soluble form. In the case of potash only twenty-six brands were found in which the small amount of chlorids present indicated the use of sulphate of potash, and these were limited to a few manufacturers.

The advance in cost of ammoniates last spring was met by increases in the Station's schedule of valuations. It is of interest, therefore, to calculate the average valuation for the past two years by means of the same schedule. Using last year's schedule, the valuations, compared with the selling prices, are shown as follows:

	Station's Valuation.	Selling Price.	Actual Difference.
1904	$20.91	$27.63	$6.72
1905	21.13	28.27	7.14

It appears, therefore, that the manufacturers are delivering, on the average, a little more plant-food than last year, at a somewhat increased price per ton.

The difference this year between the average valuation and selling price is $6.76, about the same as last year. This difference represents the average charge of the manufacturers for mixing and bagging an average of $21.51 worth of plant-food, and for dealers' commissions and other expenses incurred in effecting its sale and delivery. This is 31.4 per cent. of the value delivered. This average charge is not made in all cases, in some the valuation even exceeding the selling price. On the other hand, however, others show a charge very much higher, in a number of brands as high as 75 to 80 per cent. While these excessive prices are in many cases partially due to the dealers, the fact remains that there is a tendency on the part of certain manu-

It has already been shown that there have been slight variations in the average composition of the complete fertilizers during the past ten years. It is also of interest to determine the prices charged for the different forms of plant-food in the years covered by this period. The following tabulation shows the average cost per pound of organic nitrogen, available and insoluble phosphoric acid and potash in complete fertilizers from 1896 to the present year. It will be seen that with two exceptions there has been a steady increase in cost of organic nitrogen, the cost in 1905 being 5.1 cents per pound higher than in 1897. On the other hand, the cost of available phosphoric acid and potash has shown a decrease, the present cost of available being 1.8 cents and that of potash 0.8 cents per pound lower than in 1896. Insoluble phosphoric acid has shown little change. These variations in cost of the different plant-food elements have been met by changes in the schedule of valuations from year to year, reference to which shows that since 1896 the valuation for organic nitrogen has been advanced from 14 to 18.5 cents, while that of available phosphoric acid and potash, as muriate, has decreased from 5.5 to 4.5 cents, and from 4.5 to 4.25 cents, respectively. The valuation for insoluble phosphoric acid has remained unchanged, at two cents, for the past ten years.

Cost per Pound of Plant-Food Elements in Mixed Fertilizers, 1896-1905.

Year.	Number of Brands.	Cost per Pound. Organic Nitrogen.	Available Phos. Acid.	Insoluble Phos. Acid.	Potash as Muriate.
		cts.	cts.	cts.	cts.
1896	329	19.6	7.7	2.8	6.3
1897	284	19.0	7.5	2.7	6.1
1898	303	20.1	6.5	2.9	6.1
1899	321	19.5	6.3	2.8	5.9
1900	298	20.3	5.9	2.6	5.6
1901	308	20.5	6.4	2.6	5.5
1902	391	21.3	6.5	2.6	5.5
1903	390	22.7	6.0	2.7	5.7
1904	434	22.9	5.9	2.6	5.6
1905	380	24.1	5.9	2.6	5.5

For the past two years the Station has called attention to the frequently-observed fact that brands carrying the same guarantee often vary widely in selling price. The "unit" system was devised for purposes of comparison, the term "unit" here meaning units of plant-food furnished by the guarantee, based on the commercial valuation of the different ingredients, and is not used in the sense generally understood by this term; 1 per cent. of ammonia is counted as three units, and 1 per cent. of available phosphoric acid and potash each as one unit. The table is omitted this year, but the following is a summary of the facts shown by such a comparison. As in previous years, not to make comparisons along too narrow lines, the guarantees have been grouped into four classes—those containing from 10 to 16 units of plant-food, typified by the guarantee of 1½ per cent. ammonia, 8 available and 1½ of potash; those containing from 17 to 23 units, with an average guarantee of 2, 9, 5; those containing from 24 to 30 units, with an average guarantee of 3, 8, 9; and those containing from 31 to 48 units, with an average guarantee of 7½, 6, 6.

The wide variations between the valuations and selling prices of brands of the same guarantee are very striking. In class 1 the valuation varies from $18.94 to $11.38, and the selling price from $30 to $16. In class 2 the valuation varies from $24.99 to $15.34, and the selling price from $42 to $18.55. In class 3 the valuation varies from $30.88 to $20.91, and the selling price from $42 to $25. In class 4 the valuation varies from $42.91 to $27.69, and the selling price from $51 to $30. It is evident at once, therefore, that there are very wide variations in the amounts of plant-food furnished under the same guarantee, and even greater variations in the prices asked. While there is considerable variation in the guaranteed units in the different classes, almost as great variations are found in nearly every individual group, although these variations, as a rule, become less as the grade of the goods is raised. The above consideration indicates very clearly the necessity of the consumer comparing carefully the guarantee of the brand with the price asked for it.

The above method of comparison again emphasizes the relative cost of high and low-grade goods. Grouping the guarantees in four classes, as above, it is found that the average valuation in class 1 is $15.02, the selling price $22.24, and the average excess of the latter 48.1 per cent.; in class 2, valuation $19.51, selling price $27.26, excess 39.7 per cent.; in class 3, valuation $25.45, selling price $31.03,

excess 21.9 per cent.; and in class 4, valuation $34.16, selling price $37.97, excess 11.2 per cent. It will be observed that there is a regular decrease in the differences; in general, the lower grade goods are the more expensive. The variation in valuation and selling price per unit guaranteed for the different classes shows a similar result. In class 1 the selling price per unit exceeds the valuation by 52 cents, in class 2 by 38 cents, in class 3 by 22 cents and in class 4 by 11 cents. The same steady decrease is noticed as the grade of the goods increases.

The following tabulation was prepared to show the excess of selling price over valuation for equivalent guarantees from different manufacturers. The table includes all the brands of all manufacturers who sell brands which fall in two or more of the classes above referred to, based on the units guaranteed. It shows very clearly the marked tendency of the manufacturers to charge proportionately higher prices for lower grade goods. The average excess of selling price over valuation in low-grade fertilizers (9–16 units) was 47.1 per cent.; in medium-grade (17–23 units), 37.3 per cent.; in high-grade (24–29 units), 22.9 per cent.; and in very high-grade (30–48 units), 16.4 per cent. Of the sixty-two manufacturers whose brands are included in this table, forty-eight show a decreasing excess as the grade of the goods increases, while fourteen show either little change or no apparent system of charges. These figures emphasize the point referred to above, namely, that as a general rule the manufacturer's charges for the compounding and sale of high-grade fertilizers are, proportionately, considerably lower than in goods of poor quality. It should be remembered, however, that the same charges for freight, selling, etc., maintain for low as for high-grade fertilizers, and are therefore proportionately greater in the former, and accordingly have a greater effect on the difference between valuation and selling price.

The cost per pound of organic nitrogen, available phosphoric acid, insoluble phosphoric acid, and potash as muriate, in the average low-grade fertilizer this year was 28.7, 7.0, 3.1 and 6.6 cents, respectively; in the average medium-grade, 25.9, 6.3, 2.8 and 6.0 cents; in the average high-grade, 22.2, 5.4, 2.4 and 5.1 cents; and in the average very high-grade, 20.3, 5.0, 2.2 and 4.7 cents. This, again, confirms the statement that, generally speaking, the so-called "cheap" fertilizers are the most expensive. The cost of the higher grade goods was only slightly in advance of the Station's valuations.

Excess of Selling Price Over Valuation for Equivalent Guarantees from Different Manufacturers.

Manufacturer.	Low Grade. 9-16 Units.	Medium Grade. 17-23 Units.	High Grade. 24-29 Units.	Very High Grade. 30-48 Units.	Manufacturer.	Low Grade. 9-16 Units.	Medium Grade. 17-23 Units.	High Grade. 24-29 Units.	Very High Grade 30-48 Units.
	%	%	%	%		%	%	%	%
A	50.1	50.7	33.7	35.9	F^1	72.3	55.3	....	....
B	64.3	61.1	41.5	20.8	G^1	36.2	38.4	....	....
C	57.5	39.9	27.6	24.8	H^1	27.3	33.6	....	....
D	28.1	48.2	15.3	....	I^1	90.9	44.7	....	....
E	52.5	54.8	27.3	....	J^1	46.1	35.6	....	....
F	40.8	42.5	32.1	....	K^1	60.1	....	23.0	....
G	17.8	44.4	30.8	....	L^1	22.3	....	19.5	....
H	35.6	37.5	30.5	....	M^1	....	22.8	17.4	....
I	75.4	41.0	35.5	....	N^1	....	21.2	20.8	17.5
J	47.7	46.3	28.3	....	O^1	....	27.7	11.5	7.4
K	59.4	38.0	24.9	....	P^1	....	35.2	18.7	15.4
L	51.4	41.2	22.2	....	Q^1	....	29.1	12.4	10.4
M	55.0	76.1	30.2	....	R^1	....	26.6	14.7	12.7
N	44.0	26.1	15.4	....	S^1	....	27.5	22.4	18.0
O	52.3	46.3	11.8	....	T^1	....	28.0	25.4	....
P	64.3	57.3	31.7	....	U^1	....	35.6	24.2	26.8
Q	46.1	42.5	29.3	....	V^1	....	21.0	22.5	....
R	39.9	26.1	11.5	....	W^1	....	20.2	11.2	....
S	49.2	25.3	27.0	....	X^1	....	35.2	15.4	....
T	59.6	52.4	38.2	....	Y^1	....	49.5	66.3	....
U	45.6	42.7	21.5	....	Z^1	....	42.7	24.4	....
V	6.5	12.6	8.0	....	A^2	....	23.9	14.5	....
W	29.6	30.5	34.9	....	B^2	....	30.8	15.4	....
X	24.4	27.2	20.4	....	C^2	....	41.1	29.4	....
Y	5.5	34.9	15.2	....	D^2	....	23.9	21.6	....
Z	75.7	41.4	21.5	....	E^2	....	....	16.3	7.1
A^1	57.5	30.4	13.3	....	F^2	....	....	4.1	11.1
B^1	71.4	42.9	31.4	....	G^2	....	....	10.1	3.8
C^1	43.7	48.5	....	....	H^2	....	....	23.7	15.5
D^1	65.5	34.6	....	....	I^2	....	....	20.8	21.9
[illegible]	[illegible]	[illegible]			[illegible]			[illegible]	[illegible]

Inspections as a Guide to Purchasers.

A State inspection of fertilizers requires that at least one sample of all of the brands upon the market shall be taken and analysed each year, and the results published. The results of the inspection, therefore, show whether the manufacturers have complied with the law requiring that they shall furnish the amounts and proportions of plant-food claimed by their guarantees. The object in the purchase of fertilizers should be to secure the kind and quality of plant-food believed to be needed at the lowest cost per pound of constituent, hence an analysis which shows a compliance with the law is not a sufficient guide. There must also be confidence in the integrity of the sample and in the uniformity of the composition of individual brands, for the same season, and from year to year. Samples are representative when taken from stock, properly stored, and in considerable amounts, and in such variations in the composition of the same brand should range within narrow limits. A wide variation from the guaranteed composition of a brand, whether high or low, would indicate either that care had not been used in its preparation or that different kinds and quantities of materials had been used in the making of the different batches sold in the same season. The analyses recorded give evidence that both causes of variation have obtained this year in a number of cases. But, whatever the cause, it must of necessity create uncertainty in the minds of purchasers, and a consequent recourse to other firms or to other methods of purchase. The interest of both producers and consumers is conserved only when confidence is established in these respects. It is only those brands that are uniform in composition that are worthy of the highest confidence.

FORMS OF NITROGEN.

Readily and Completely Soluble in Water.

Station Number.	FROM WHOM RECEIVED.	Percentage of Nitrogen.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Material.
	Nitrate of Soda.	$	cts.	
5034	C. S. Lee, Hightstown	15.67	15.95	$50 00
5058	J. B. Warrick, Moorestown	15.78	13.67	43 00
5128	H. H. Hutchinson, Robbinsville	15.67	15.47	48 50
5186	J. S. Collins & Son, Moorestown	15.79	16.47	52 00
5188	J. W. Pincus, Woodbine	15.55	16.08	50 00
5214	College Farm, New Brunswick	15.90	15.72	50 00
5217	Jos. Adams, Glassboro	15.53	16.69	52 00
5249	S. L. Pancoast, Mullica Hill	15.48	16.80	52 00
5374	W. M. Wilde, Vineland	15.71	16.55	52 00
5395	P. J. Fitting, Hammonton	[1]14.64	*17.40	55 00
5497	C. C. Hulsart, Matawan	[2]13.67	*14.97	46 00
5575	J. H. Baird, Marlboro	15.26	16.38	50 00
5636	W. T. Hageman, Readington	15.41	16.87	52 00
5692	Ira Hill, Copper Hill	[3]13.86	*18.73	54 00
	Average Cost per Pound		16.06	
	Sulphate of Ammonia.			
5050	J. B. Warrick, Moorestown	20.64	15.16	62 60

* Not included in the average, and allowing 5 cents per pound for the potash.

[1] Contains 4.77 per cent. potash and 4.01 per cent. chlorin.

[2] Contains 5.96 per cent. potash and 5.28 per cent. chlorin.

[3] Contains 2.45 per cent. potash and 4.72 per cent. chlorin.

		Percentage of Nitrogen.	Percentage of Potash.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Material.
	Nitrate of Potash.				
5215	College Farm, New Brunswick	12.76	45.24	†11.66	$75.00

† Five cents per pound allowed for the potash

FORMS OF NITROGEN INSOLUBLE IN WATER.

Station Number.	FROM WHOM RECEIVED.	Percentage of Nitrogen.	Percentage of Phosphoric Acid.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Material.
	Dried Blood.	%	%	cts.	
5027	C. H. Conover, Hightstown	11.36	0.95	18.15	$42 00
5030	C. A. Mason, Cranbury	9.98	7.68	....	42 00
5035	C. S. Lee, Hightstown	10.45	7.45	....	42 00
5039	A. E. Perrine, Cranbury	11.88	3.72	....	42 00
5049	J. B. Warrick, Moorestown	13.11	0.42	17.80	47 00
5125	H. H. Hutchinson, Robbinsville	12.65	1.44	15.36	40 00
5596	Hendrickson & Dilatush, Robbinsville	10.17	0.90	20.29	42 00
	Average Cost per Pound			17.90	
	Dried and Ground Fish.				
5031	C. A. Mason, Cranbury	9.09	7.37	17.38	37 50
5040	A. E. Perrine, Cranbury	9.25	6.51	17.45	37 50
5126	H. H. Hutchinson, Robbinsville	9.55	6.38	16.13	36 00
5134	J. S. Collins & Son, Moorestown	5.85	6.25	26.50	36 00
†5187	" " " "	5.69	4.16	*17.28	23 00
5169	Collins & Pancoast, Merchantville	5.87	6.44	25.43	35 00
5372	W. M. Wilde, Vineland	8.79	7.82	17.49	37 00
5434	*Saalman Bros., Egg Harbor City*	8.92	6.26	19.33	39 50
†5433	Chas. Cast, Egg Harbor City	2.95	7.14	*34.39	26 00
5437	Jos. Sahl, Egg Harbor City	6.22	6.73	22.60	33 50
5436	Fruit Growers' Union, Cologne	5.54	4.64	23.73	30 00
5226	Hiram Clement, Woodbury	7.04	6.10	19.97	33 00
5399	Geo. Elvins, Hammonton	8.21	7.84	18.35	36 00
5499	C. A. Geran, Matawan	5.93	5.88	25.89	35 00
5496	C. C. Hulsart, Matawan	8.65	7.48	14.46	31 00
†5565	H. W. Van Artsdalen, Titusville	3.58	5.10	*31.06	26 00
5630	W. H. Brewer, Ringoes	9.34	5.90	15.09	32 90
5333	Jos. Camp. Pierces (crab)	9.86	0.91	*12.96	25 00
5005	G. M. Wells, Moorestown	5.40	6.14	21.38	28 00
	Average Cost per Pound			20.08	

Four cents per pound allowed for the phosphoric acid.

*Not included in the average.

†Crude or raw fish.

FORMS OF NITROGEN INSOLUBLE IN WATER.

TANKAGE.

Station Number.	FROM WHOM RECEIVED.	MECHANICAL ANALYSIS. Finer than $\frac{1}{50}$ inch.	MECHANICAL ANALYSIS. Coarser than $\frac{1}{50}$ inch.	PERCENTAGE. Nitrogen.	PERCENTAGE. Phosphoric Acid.	Cost of 2,000 lbs. of Material.
				%	%	
5087	C. S. Lee, Hightstown	68	37	5.52	18.71	$26 25
5041	A. E. Perrine, Cranbury	62	38	6.18	9.77	26 25
5028	C. H. Conover, Hightstown	57	43	5.88	11.10	26 25
5129	H. H. Hutchinson, Robbinsville	83	17	5.11	18.52	25 00
5189	J. W. Pincus, Woodbine	64	36	7.18	18.08	30 00
5371	W. M. Wilde, Vineland	...	...	5.86	14.84	26 00
5435	Saalman Bros., Egg Harbor City	...	...	4.78	17.56	27 00
5495	C. C. Hulsart, Matawan	66	34	5.93	11.84	24 50
5404	Edward Cathcart, Hammonton	60	40	4.10	19.70	31 00
5637	W. T. Hageman, Readington	76	24	6.89	11.90	31 00
5595	Hendrickson & Dilatush, Robbinsville	50	50	5.79	18.38	27 00
5690	J. Q. Holcombe, Ringoes	58	42	5.15	14.34	24 25
5693	Ira Hill, Copper Hill	38	62	6.81	5.82	24 00
5694	" " " "	42	58	5.17	11.88	25 00
5772	J. H. Denise, Freehold	60	40	7.60	12.38	28 50
5843	J. F. Hutchinson, Windsor	48	52	6.17	16.73	26 00
5856	W. H. Brewer, Ringoes	75	24	4.92	17.85	22 50

Station Number.		COST OF NITROGEN PER LB. IN— Finer than $\frac{1}{50}$ inch.	COST OF NITROGEN PER LB. IN— Coarser than $\frac{1}{50}$ inch.	COST OF PHOSPHORIC ACID PER LB. IN— Finer than $\frac{1}{50}$ inch.	COST OF PHOSPHORIC ACID PER LB. IN— Coarser than $\frac{1}{50}$ inch.
		cts.	cts.	cts.	cts.
5087	Tankage	16.98	12.26	3.77	2.83
5041	"	17.52	12.65	3.89	2.92
5028	"	17.76	12.88	3.95	2.96
5129	"	14.22	10.27	3.16	2.37
5189	"	16.32	11.79	3.63	2.72
5495	"	15.78	11.40	3.51	2.63
5404	"	20.46	14.78	4.56	3.41
5637	"	17.40	12.57	3.87	2.90
5595	"	18.84	13.61	4.19	3.14
5690	"	16.38	11.83	3.64	2.73
5693	"	17.82	12.87	3.96	2.97
5694	"	18.96	13.69	4.21	3.16
5772	"	15.42	11.14	3.43	2.57
5843	"	15.26	11.02	3.39	2.54
5856	"	13.68	9.88	3.04	2.28
	Average Cost per Pound	16.85	12.17	3.75	2.81

PLAIN SUPERPHOSPHATES.

Furnishing Soluble, Reverted and Insoluble Phosphoric Acid.

Station Number.	FROM WHOM RECEIVED.	PHOSPHORIC ACID.				Cost of Available Phosphoric Acid per lb.	Cost of 2,000 lbs. of Material.
		Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Available.		
		%	%	%	%	cts.	
5083	C. A. Mason, Cranbury	11.80	2.00	0.59	13.80	3.55	$9 80
5062	J. B. Warrick, Moorestown	11.68	2.77	1.05	14.45	3.11	9 00
5180	H H. Hutchinson, Robbinsville	12.56	1.85	1.38	14.41	3.23	9 80
5186	J. W. Pincus, Woodbine	11.76	4.37	1.68	16.13	2.79	9 0C
5378	W. M. Wilde, Vineland	10.96	2.53	2.08	13.49	4.45	12 00
5576	J. H. Baird, Marlboro.	13.10	1.65	1.70	14.75	3.73	11 00
5638	W. T. Hageman, Readington[1]	12.76	1.79	2.37	14.55	3.49	10 15
5631	W. H. Brewer, Ringoes.	12.20	2.42	2.68	14.62	3.51	10 25
5597	Hendrickson & Dilatush, Robbinsville	11.82	3.30	1.40	15.12	*4.30	13 00
5689	W. Y. Holt, Flemington	12.24	2.89	1.15	15.13	3.27	9 90
5774	J. H. Denise, Freehold	12.08	3.27	2.24	15.35	3.58	11 00
5598	Wm. Petty, Cranbury[2]	11.76	2.78	1.09	14.54	*4.81	14 00
5242	J. K. Waddington, Salem	11.86	2.09	1.08	13.95	4.30	12 00
5701	A. A. Cortelyou, Neshanic	11.68	3.51	0.78	15.19	3.95	12 00
5676	O. H. Dilts, Ringoes[3]	9.24	3.32	3.58	12.56	*5.38	13 50
5205	E. S. Dobbs, Gloucester[4]	9.48	4.24	1.90	13.72	*5.10	14 00
5712	J. Q. Holcombe, Ringoes[5]	11.18	4.10	2.84	15.28	3.27	10 00
5721	David Carling, Bloomsbury	11.72	3.85	0.84	15.57	*4.14	13 00
5732	J. C. Voorhees, White House	11.84	2.29	0.64	14.13	*4.60	13 00
5845	J. F. Hutchinson, Windsor	12.82	2.27	0.87	14.59	3.43	10 00
5557	W. H. Brewer, Ringoes	12.70	2.17	1.12	14.87	3.40	10 10
5682	Peter Abel, Everittstown[6]	10.44	3.18	3.66	13.62	*5.14	14 00
	Average Cost per Pound					3.54	

* Not included in the average.

[1] Nassau Soluble Bone Phosphate.

[2] Armour's Star Phosphate.

[3] O. H. Dilts' Soluble Bone Phosphate.

[4] Packers' Union Acidulated Bone.

[5] Reese's Elm Phosphate.

[6] Quinnipiac Soluble Dissolved Bone.

GERMAN POTASH SALTS.

Station Number.	FROM WHOM RECEIVED.	Percentage of Potash.	Cost of Potash per lb.	Cost of 2,000 lbs. of Material.
	Muriate of Potash.	%	cts.	
5088	C. S. Lee, Hightstown	50.45	4.16	$42 00
5051	J. B. Warrick, Moorestown	49.81	3.71	37 00
5127	H. H. Hutchinson, Robbinsville	46.57	4.29	40 00
5190	J. W. Pincus, Woodbine	47.14	4.14	39 00
5875	W. M. Wilde, Vineland	†38.92	*5.14	40 00
5860	W. M. Wilde, Vineland	47.58	4.21	40 00
5481	Peter Barclay, Cranbury	47.48	4.48	42 50
5639	W. T. Hageman, Readington	49.15	4.20	41 25
5632	W. H Brewer, Ringoes	45.78	4.40	40 25
5695	Ira Hill, Copper Hill	42.45	4.71	40 00
5771	John Leed, Elm	50.72	4.14	42 00
5846	J. F. Hutchinson, Windsor	53.18	3.85	41 00
5855	W. H, Brewer, Ringoes	51.97	3.82	39 75
	Average Cost per Pound		4.18	
5187	**High-Grade Sulphate of Potash.**			
	J. W. Pincus, Woodbine	51.26	4.39	45 C0
	Kainit.			
5048	A. E. Perrine, Cranbury	13.23	4.44	11 75
5082	J. J. Hitchner, Daretown	13.55	3.91	10 60
5407	Troth & Keen, Millville	12.74	4.71	12 00
5498	C. C. Hulsart, Matawan	11.78	4.67	11 00
5578	J. H. Baird, Marlboro	12.57	*5.17	13 00
5633	W. H Brewer, Ringoes	15.20	3.62	11 00
5691	J. Q. Holcombe, Ringoes	15.24	3.53	10 75
5696	Ira Hill, Copper Hill	13.02	4.61	12 00
5854	W. H. Brewer, Ringoes	13.09	3.82	10 00
			4.16	

* Not included in the average.

† Contains nitrates.

Home Mixtures and Special Compounds

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
***HOME MIXTURES.**		
Sylvanus Apgar, Mt. Pleasant	Mt. Pleasant	5858
Henry Bauer, Burlington (Potatoes)	Burlington	5769
" " " (Corn and Wheat)	"	5770
H. H. Bell, Mt. Ephraim	Mt. Ephraim	5159
" " " "	" "	5158
G. A. Bennett, Cranbury (No. 1)	Cranbury	5814
" " " (No. 2)	"	5815
P. J. Fitting, Hammonton	Hammonton	5896
Jos. Gubbins	Gloucester	5046
L. H. Stemler, Matawan	Matawan	5494
J. B. Warrick, Moorestown	Moorestown	5458
SPECIAL COMPOUNDS.		
American Agricultural Chemical Co., New York City.		
Bergen Grange Mixture for Corn and Grass	River Edge	5775
Special Fish	Woodbine	5886
Baugh & Sons' Co., Philadelphia, Pa.		
Gloucester Co. Grange White Potato Fertilizer	Mickleton	5767
" " " Sweet Potato Fertilizer	"	5768
Fords' Home Mixture	Allentown	5518
Made for Elmer Grange, Elmer, N. J.		
Potato Manure No. 1	Elmer	5314
" " No. 2	"	5315
Samuel Lederer & Son, New Brunswick, N. J.		
Garden Truck Fertilizer	Jamesburg	5311
Corn Fertilizer	"	5312
Potato Fertilizer	"	5313
Nassau Fertilizer Co., New York City.		
Pomona Grange Potato Mixture	Phillipsburg	5272
" " Grain Mixture	"	5273
" " No. 1	"	5847
Schomp's Special Mixture	Readington	5849
I. P. Thomas & Son Co., Philadelphia, Pa.		
Schomp's Special Mixture	Readington	5848
Trenton Bone Fertilizer Co., Trenton, N. J.		
Ewing Grange Mixture	Trenton	5835
F. W. Tunnell & Co., Philadelphia, Pa.		
Grass Mixture	Moorestown	5065
Special Ammoniated Bone and Potash	Califon	5728
Complete Superphosphate	Titusville	5570
Sweet Potato Manure	Swedesboro	5289

* For formulas see page 25.

Home Mixtures and Special Compounds

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.24	......	1.84	2.08	......	3.02	8.08	2.67	13.72	....	11.05	....	2.49	....	$20 77	†$19 24
1.66	1.27	0.65	3.58	......	4.95	5.08	1.84	11.33	....	9.99	....	*10.51	....	32 04	†27 85
0.48	......	3.91	4.39	......	0.00	10.67	10.53	21.20	....	10.67	....	6.48	....	34 57	†33 50
1.06	0.34	1.00	2.40	......	4.04	1.95	0.55	6.54	....	5.99	....	6.54	....	....	....
0.63	0.20	1.36	2.19	......	1.16	2.19	0.34	3.69	....	3.35	....	4.54	....	....	....
0.77	......	2.92	3.69	......	3.00	4.37	2.48	9.85	....	7.37	....	10.38	....	29 86	†29 00
0.77	......	1.89	2.66	......	5.42	3.82	1.91	11.15	....	9.24	....	8.47	....	25 89	†27 00
......	......	2.11	2.11	......	3.48	5.77	3.67	12.92	....	9.25	....	6.02	....	22 72	†21 00
......	......	1.55	1.55	1.64	2.52	2.54	1.00	7.06	5.00	6.06	....	1.62	3.00	....	10 50
2.13	......	1.95	4.08	......	5.00	2.46	3.24	10.70	....	7.46	....	7.37	....	28 74	†25 50
1.30	1.03	0.81	3.14	......	3.68	6.86	2.18	12.72	....	10.54	....	9.65	....	23 58	†24 65
0.87	0.90	1.14	2.91	3.28	8.54	1.16	1.27	10.97	....	9.70	9.00	4.69	4.00	23 56	26 10
0.89	0.22	1.34	2.45	3.28	3.80	0.98	1.11	5.89	....	4.78	5.00	1.36	1.00	14 66	20 00
0.79	0.97	1.27	3.03	3.28	5.42	3.71	1.26	10.38	....	9.13	7.00	8.45	8.75	26 69	27 85
......	......	1.66	1.66	1.64	6.94	2.31	1.64	10.89	....	9.25	8.00	10.29	10.00	23 88	24 75
1.28	1.99	0.57	3.84	3.69	9.54	0.75	0.17	10.46	....	10.29	9.00	*8.86	10.00	30 53	38 00
0.82	1.04	1.23	3.09	3.28	5.98	3.71	1.33	11.02	....	9.69	7.00	*9.09	8.75	29 32	28 75
0.99	......	1.70	2.69	2.87	7.88	0.81	1.22	9.91	....	8.69	7.50	*8.90	8.00	26 87	26 75
2.90	......	1.31	4.21	4.92	2.82	2.96	1.61	7.39	12.00	5.78	8.00	6.63	5.00	26 19	26 00
1.47	0.25	1.14	2.86	2.46	3.28	3.69	2.32	9.29	10.00	6.97	8.00	5.12	7.00	21 65	24 00
0.47	0.36	1.15	1.98	3.28	3.32	4.77	4.05	12.14	10.00	8.09	7.00	6.55	7.00	20 74	25 00
0.83	......	1.48	2.31	2.46	8.12	1.12	0.74	9.98	9.00	9.24	8.00	*8.95	8.00	25 87	26 50
......	0.35	1.57	1.92	1.64	6.84	1.59	1.90	10.33	9.00	8.43	8.00	4.87	4.00	19 53	19 40
0.56	......	1.43	1.99	2.05	6.82	2.38	1.75	10.96	....	9.20	8.00	6.06	6.00	21 32	21 75
......	......	0.42	0.42	......	5.36	6.08	2.64	14.08	....	11.44	....	4.09	....	16 38	‡21 61
9.14	......	0.99	10.13	......	0.00	4.54	1.85	6.39	....	4.54	....	1.03	....	41 57	†45 00
1.04	......	2.29	3.33	3.28	3.26	4.73	3.29	11.28	9.00	7.99	....	10.06	10.00	29 07	32 50
2.59	......	1.00	3.59	......	0.40	5.42	3.77	9.59	....	5.82	....	....	....	19 36	28 25
......	......	0.65	0.65	0.21	0.48	4.38	1.74	6.60	10.00	4.86	9.00	1.49	2.00	8 75	120 00
......	......	2.25	2.25	0.82	9.28	2.44	2.24	13.96	10.00	11.72	9.00	3.10	1.75	22 41	....
0.97	1.24	0.71	2.92	2.05	6.16	2.88	1.08	10.07	8.00	9.04	8.50	*10.47	8.00	29 39	....

*Potash largely, if not entirely, from sulphate. †Cost price. ‡Manufacturer claims retail price should be $45.00.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
American Agricultural Chemical Co., New York City.		
Monmouth Co. Special Fertilizer	Jerseyville	5088
Special Tomato Fertilizer	Keyport	5523
Special Potash Mixture	Belvidere	5665
Ten Per Cent. Potato Manure	Bridgeton	5274
Superior Fish Guano	Quinton	5286
* " " "	Swedesboro	5268
Special Lawn Dressing	Burlington	5182
Ten Per Cent. Vegetable and Potato Manure	Matawan	5522
Zell's Special Compound for Potatoes and Vegetables	"	5551
Wheat and Hay Maker	Plainsboro	5552
Bradley Branch.		
Complete Manure with Ten Per Cent. Potash	West Long Branch	5466
Potato Manure	Matawan	5528
Complete Manure for Potatoes and Vegetables	Keyport	5529
"B" Fertilizer	West Long Branch	5465
Ammoniated Dissolved Bone	Matawan	5527
New Method Fertilizer	Keyport	5580
Chemical Co. of Canton Branch.		
Special Compound	Cologne	5440
Truckers' Delight	"	5441
Chicopee Branch.		
A1 Vegetable and Potato Manure	Elmer	5340
Clark's Cove Branch.		
King Philip Alkaline Guano	Quinton	5277
Great Planet Fertilizer	Keyport	5583
Unicorn Fertilizer	Englishtown	5004
Potato Phosphate	Keyport	5582
Fish and Potash	Matawan	5584
Crocker Branch.		
Special Potato Manure	Marlboro	5065
New Rival Fertilizer	"	5084
Cabbage and Potato Manure	Paterson	5806
East India Branch.		
Potato Manure	Hightstown	5610
"AA" Ammoniated Superphosphate	Keyport	5068
* " " "	Red Bank	5563

* Duplicate sample.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.58	0.91	1.67	3.16	3 28	6.48	0.80	0.85	8.13	7.00	7.28	6.00	10.82	10.00	$27 43	$29 00
......	......	0.95	0.95	0.82	6.94	1.63	2.14	10.71	9.00	8.57	8.00	4.14	4.00	16 61	20 00
......	......	0.92	0.92	0.82	8.10	1.87	1.44	10.91	10.00	9.47	9.00	6.93	7.00	18 40	24 00
.....	......	1.55	1.55	1.64	4.00	0.94	1.23	6.17	6.00	4.94	5.00	9.78	10.00	19 03	30 00
......	......	2.71	2.71	3.28	4.78	0.76	1.08	6.62	6.00	5.54	5.00	1.38	1.00	16 62	23 00
0.90	......	1.91	2.81	3.28	4.12	1.12	1.06	6.30	6.00	5.24	5.00	1.59	1.00	16 62	25 00
1.86	.....	0.66	2.52	2.87	0.20	3.55	7.27	11.02	11.25	3.75	....	2.15	2.00	16 85	....
0.21	0.22	1.28	1.66	1.64	7.24	1.51	1.50	10.25	9.00	8.75	8.00	8.84	10.00	22 01	31 00
0.38	......	2.07	2.40	2.46	6.48	2.74	1.72	10.94	9.00	9.22	8.00	5.05	4.00	22 06	30 00
0.33	0.41	1.67	2.41	1.64	6.56	2.49	1.81	10.86	11.00	9.05	10.00	9.16	10.00	25 39	....
0.21	1.17	1.94	3.32	3.28	6.00	1.07	0.77	7.84	7.00	7.07	6.00	9.24	10.00	26 51	32 00
0.60	....	1.83	2.43	2.46	5.12	1.16	1.61	7.89	7.00	6.28	6.00	6.55	6.00	20 67	32 00
0.58	0.44	1.99	3.01	3.28	7.14	1.22	0.99	9.35	9.00	8.36	8.00	6.63	7.00	24 43	34 00
......	......	0.97	0.97	0.82	4.94	2.67	2.97	10.58	9.00	7.61	8.00	3.99	4.00	15 02	25 00
......	......	1.67	1.67	1.64	5.40	2.51	2.81	10.72	9 00	7.91	8.00	2.00	2.00	16 12	25 00
.....	......	1.06	1.06	0.82	6.64	2.05	4.52	13.21	9.00	8.69	8.00	2.24	2.00	15 45	21 00
0.54	......	1.24	1.78	2.05	5.48	2.49	1.66	9.63	9.00	7.97	8.00	5.89	6.00	19 27	30 00
0.63	......	1.61	2.24	2.46	5.26	2.49	1.43	9.18	9.00	7.75	8.00	4.44	4.00	19 42	30 00
0.68	0.29	1.33	2.30	2.46	4.16	1.55	1.30	7.01	7.00	5.71	6.00	10.91	10.00	23 18	29 00
0.20	......	0.91	1.11	1.03	5.00	2.62	1.80	9.42	9.00	7.62	8.00	2.34	2.00	13 62	21 00
......	1.47	1.64	3.11	3.28	7.32	1.28	1.74	10.34	9.00	8.60	8.00	7.14	7.00	25 73	34 00
......	......	1.77	1.77	1.64	7.96	0.85	2.93	11.74	9.00	8.81	8.00	2.35	2.00	17 65	22 00
......	0.90	1.47	2.37	2.46	5.00	2.23	1.22	8.45	7.00	7.23	6.00	6 51	6.00	21 12	30 00
.....	0.20	1.86	2.06	1.64	6.44	1.69	1.67	9.80	9.00	8.13	8.00	2.19	2.00	17 40	25 00
0.96	0.83	1.09	2.87	3.28	5.92	1.42	2.00	9.34	9.00	7.34	8.00	6.30	7.00	22 94	30 00
......	......	1.33	1.33	1.23	6.90	2.39	2.38	11.67	11.00	9.29	9.00	2.25	2.00	16 13	19 00
......	.....	2.32	2.32	2.46	7.20	1.28	1.95	10.43	9.00	8.48	8.00	6.08	6.00	22 16	32 00
......	1.36	1.71	3.07	3.28	4.88	2.13	1.17	8.18	7.00	7.01	6 00	11.19	10.00	27 38	34 00
......	......	2.03	2.03	2.46	7.44	2.05	2.13	11.62	11.00	9.49	9.00	2.68	2.00	19 13	26 00
......	......	2.24	2.24	2.46	6.70	2.11	3.34	12.15	11.00	8.81	9.00	1.33	2.00	19 63	28 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
American Agricultural Chemical Co., N. Y. City— (Cont.)		
East India Branch—(Cont.)		
Turnip Manure	Red Bank	5506
* " "	Keyport	5587
Great Eastern Branch.		
Vegetable, Vine and Tobacco	Erma	5409
* " " " "	Toms River	5469
Milsom Branch.		
Corn Fertilizer	Newton	5620
Pacific Guano Branch.		
Ammoniated Dissolved Bone	Millington	5752
Packers' Union Branch.		
Gardeners' Complete Manure	Fairton	5829
Universal Fertilizer	Baptisttown	5680
Potato Manure	Gloucester	5207
Animal Corn Fertilizer	Ridgewood	5797
Moro Phillips Branch.		
Superior Fish Guano	Elmer	5851
Sweet Potato Manure	Vineland	5892
N. J. Potato Manure	Cold Spring	5412
Special Fertilizer	Fishing Creek	5413
Fish Guano	Pomona	5442
Preston Branch.		
Potato and Onion Fertilizer	Cold Spring	5414
Quinnipiac Branch.		
Market Garden Manure	Quinton	5284
Read Branch.		
Bone, Fish and Potash	Elmer	5852
Farmers' Friend Superphosphate	Pomona	5443
Leader Blood and Bone	Three Bridges	5716
Corn, Wheat and Rye Fertilizer	Blairstown	5825
Standard Superphosphate	Three Bridges	5717
Practical Potato Special	Blairstown	5824
Reese Branch.		
Half and Half	Califon	5714
Mayflower	"	5713
Standard	"	5715

* Duplicate sample.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	1.76	3.17	4.93	5.74	6.08	0.72	0.92	7.72	6.00	6.80	5.00	9.36	9.00	$32 33	$41 00
......	2.11	2.83	4.94	5.74	5.86	0.86	0.90	7.62	6.00	6.72	5.00	9.26	9.00	32 14	41 00
0.53	......	1.15	1.68	2.05	6.28	1.92	1.04	9.24	9.00	8.20	8.00	3.24	3.00	16 61	27 00
......	......	2.07	2.07	2.05	7.36	1.79	2.39	11.54	9.00	9.15	8.00	3.02	3.00	19 42	26 00
......	0.89	1.36	2.25	2.46	8.44	1.11	1.28	10.83	11.00	9.55	9.00	2.71	2.00	19 56	26 00
......	......	1.68	1.68	1.64	5.78	2.36	2.08	10.22	9.00	8.14	8.00	2.15	2.00	16 21	21 00
0.83	......	2.20	3.03	3.28	4.20	2.47	1.25	7.92	7.00	6.67	6.00	11.02	10.00	26 33	35 00
......	......	0.93	0.93	0.82	7.44	1.78	2.63	11.85	9.00	9.22	8.00	4.04	4.00	16 22	22 00
0.55	......	1.21	1.76	2.05	5.38	2.46	1.39	9.23	9.00	7.84	8.00	6.00	6.00	19 07	26 00
......	......	2.06	2.06	2.46	7.60	1.74	1.62	10.96	11.00	9.34	9.00	2.40	2.00	18 72	25 75
0.94	......	2.04	2.98	3.28	4.46	0.80	1.16	6.42	6.00	5.26	5.00	1.42	1.00	17 14	24 00
0.46	......	0.99	1.45	1.64	6.20	1.84	1.28	9.32	9.00	8.04	8.00	9.67	10.00	21 20	28 00
0.57	......	1.00	1.57	1.64	4.02	3.33	2.03	9.38	9.00	7.35	8.00	9.20	10.00	20 33	29 00
0.64	......	1.20	1.84	2.05	5.84	2.12	1.30	9.26	9.00	7.96	8.00	3.06	3.00	16 93	24 00
......	......	1.58	1.58	1.85	4.66	1.68	1.17	7.51	6.00	6.34	6.00	1.34	1.00	13 63	20 00
0.86	......	1.47	2.33	2.46	3.52	2.40	1.47	7.39	7.00	5.92	6.00	5.85	6.00	19 34	28 00
0.41	1.08	1.59	3.08	3.28	5.68	1.98	1.44	9.10	9.00	7.66	8.00	6.56	7.00	24 44	30 00
0.72	......	1.52	2.24	2.46	4.08	2.10	1.16	7.34	7.00	6.18	6.00	6.06	6.00	19 34	27 00
0.53	......	1.28	1.81	2.05	5.80	2.09	1.36	9.25	9.00	7.89	8.00	2.93	3.00	16 65	26 75
......	......	0.96	0.96	0.82	6.76	1.38	3.07	11.21	8.00	8.14	7.00	1.56	1.00	23 44	30 00
......	......	1.55	1.55	1.64	7.02	1.53	2.79	11.34	9.00	8.55	8.00	4.05	4.00	17 98	26 00
......	......	1.02	1.02	0.82	6.62	1.55	3.29	11.46	9.00	8.17	8.00	4.07	4.00	15 90	21 00
......	......	0.83	0.83	0.82	2.32	1.86	2.43	6.61	5.00	4.18	4.00	9.36	8.00	15 67	25 00
......	0.19	0.80	0.99	0.82	2.80	3.80	2.67	9.27	8.00	6.60	7.00	1.63	1.00	12 07	21 00
......	......	1.59	1.59	1.64	7.14	1.30	1.35	9.79	9.00	8.44	8.00	2.25	2.00	15 95	25 00
......	......	2.27	2.27	2.46	6.86	2.17	3.03	12.06	11.00	9.03	9.00	2.73	2.00	20 06	27 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
American Agricultural Chemical Co.—(Cont.)		
Sharpless and Carpenter Branch.		
No. 1 Bone Phosphate	Quinton	5801
Gilt Edge Potato and Tobacco Manure	Swedesboro	5265
Fish Guano	Matawan	5542
Soluble Tampico Guano	Swedesboro	5266
Dissolved Bone Phosphate for Potatoes and General Use	Vineland	5886
Farmers' Bone Phosphate	Baptisttown	5684
No. 2 for Grain and Grass	Bound Brook	5719
Potato, Corn and Truck Guano	Swedesboro	5264
Farmers' Improved Potato Manure	"	5267
Potato and Truck Manure	Matawan	5517
Susquehanna Branch.		
Potato Phosphate	Califon	5722
Tygert-Allen Branch.		
Special Brand Potato Manure	Collingswood	5156
Marine Guano	Matawan	5547
Star Bone Phosphate	Bridgeton	5295
Fish, Bone and Potash	Pleasantville	5477
Sweet Potato Manure	"	5480
Ten Per Cent. Guano	Collingswood	5154
Standard Bone Phosphate	"	5155
Seven Per Cent. Guano	"	5157
Star Guano	Bridgeton	5294
Popular Phosphate	Pleasantville	5479
Peerless Potato Manure	"	5481
Superior Fish Guano for Broadcasting	Jackson's Mills	5482
Wheeler Branch.		
Special Vegetable Manure	Sewell	5289
Corn Fertilizer	Edgewater Park	5019
Sweet Potato Manure	Toms River	5489
Potato Manure	Swedesboro	5296
Williams and Clark Branch.		
Americus Fertilizer	Oceanport	5491
Royal Bone Phosphate	Pittstown	5698
Potato Phosphate	Rahway	5755
Americus Universal Ammoniated Dissolved Bone	Westwood	5798
Americus High-Grade Special Fertilizer	Adelphia	5124
Prolific Fertilizer	Annandale	5727
"B" Fertilizer	Martinsville	5757

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.37	......	1.27	1.64	1.64	6.10	1.88	1.64	9.62	9.00	7.98	8.00	2.23	2.00	$15 70	$22 00
0.40	......	1.14	1.54	1.64	6.32	1.70	1.20	9.22	9.00	8.02	8.00	10.56	10.00	22 26	27 00
0.30	......	1.46	1.76	2.05	8.02	1.05	1.48	10.55	9.00	9.07	8.00	6.30	6.00	20 53	30 00
1.17	......	1.82	2.99	3.28	3.98	3.56	2.03	9.57	9.00	7.54	8.00	7.15	7.00	24 39	31 00
0.54	......	1.22	1.76	2.05	5.14	2.48	1.54	9.16	9.00	7.62	8.00	5.41	6.00	15 43	27 00
......	0.20	0.76	0.96	0.82	4.20	3.43	2.19	9.82	9.00	7.63	8.00	3.95	4.00	14 62	21 00
......	......	1.03	1.03	0.82	3.24	3.26	2.98	9.42	8.00	6.49	7.00	1.43	1.00	12 04	20 00
......	......	1.14	1.14	1.23	3.42	2.69	1.51	7.62	7.00	6.11	6.00	6.35	5.00	15 72	22 00
1.09	......	1.84	2.93	3.28	4.48	2.10	1.23	7.81	7.00	6.58	6.00	9.39	10.00	24 91	32 00
0.67	0.73	0.72	2.12	2.46	6.62	1.51	1.73	9.86	9.00	8.13	8.00	10.42	10.00	24 38	34 00
......	......	1.59	1.59	1.64	7.02	2.01	2.67	11.70	9.00	9.03	8.00	5.00	5.00	19 33	28 00
0.59	......	1.35	1.94	2.05	5.16	2.39	1.49	9.04	9.00	7.55	3.00	6.35	6.00	19 80	28 00
0.49	1.15	1.71	3.35	3.28	4.10	3.94	2.74	10.78	9.00	8.04	8.00	6.84	7.00	26 18	35 00
0.80	......	1.12	1.92	2.05	5.12	2.73	1.68	9.53	9.00	7.85	8.00	3.04	3.00	17 17	25 00
0.72	......	1.28	2.00	2.46	7.14	1.63	1.67	10.44	11.00	8.77	9.00	2.02	2.00	17 47	28 00
0.47	......	1.10	1.57	1.64	5.14	2.56	2.40	10.10	9.00	7.70	8.00	10.06	10.00	22 11	28 00
......	3.69	3.67	7.36	8.20	3.58	1.07	0.98	5.58	5.00	4.65	4.00	4.64	4.00	34 99	45 00
0.64	......	1.00	1.64	1.64	5.80	2.11	1.56	9.47	9.00	7.91	8.00	2.73	2.00	15 98	25 00
2.23	......	2.42	4.65	5.74	4.40	1.95	1.27	7.62	7.00	6.35	6.00	4.44	5.00	26 52	38 00
0.94	......	0.88	1.82	2.05	5.50	2.61	1.51	9.62	9.00	8.11	8.00	3.16	3.00	17 05	25 00
0.50	......	0.59	1.09	0.82	4.60	3.08	1.94	9.62	9.00	7.68	8.00	2.72	2.00	13 90	20 00
0.54	......	0.88	1.42	1.64	5.10	2.76	2.44	10.30	9.00	7.86	8.00	8.01	10.00	19 96	28 00
1.08	......	1.56	2.64	3.28	4.36	1.20	1.09	6.65	6.00	5.56	5.00	1.68	1.00	16 30	26 00
0.34	......	1.20	1.54	1.64	6.08	2.18	1.74	10.00	9.00	8.26	8.00	10.22	10.00	22 42	28 00
0.45	......	1.15	1.60	1.64	6.36	1.82	1.14	9.32	9.00	8.18	8.00	2.44	2.00	15 68	25 00
......	......	2.30	2.30	2.05	6.62	1.75	1.87	10.24	9.00	8.37	8.00	5.45	6.00	21 43	27 00
0.78	......	1.03	1.81	2.05	5.90	1.84	1.50	9.24	9.00	7.74	8.00	3.12	3.00	16 63	25 00
......	......	2.29	2.29	2.46	6.84	2.50	3.18	12.52	11.00	9.34	9.00	2.20	2.00	20 03	26 00
......	......	1.18	1.18	1.03	7.04	1.48	2.15	10.62	9.00	8.47	8.00	2.18	2.00	14 70	20 00
......	1.01	1.29	2.30	2.46	3.50	2.85	3.33	9.18	7.00	5.65	6.00	7.17	6.00	20 89	32 00
......	......	1.59	1.59	1.64	5.22	2.63	2.42	10.27	9.00	7.85	8.00	2.53	2.00	16 06	24 00
1.31	1.10	0.83	3.24	3.28	6.42	1.76	1.70	9.88	9.00	8.18	8.00	7.00	7.00	25 36	31 00
......	......	1.02	1.02	0.82	1.36	4.83	3.69	9.88	9.00	6.19	7.00	1.37	1.00	11 98	19 00
......	......	0.93	0.93	0.82	6.54	1.48	3.26	11.28	9.00	8.02	8.00	4.13	4.00	15 47	25 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
J. H. Allen and Son, Lawrence Station, N. J.		
Potato and Truck Manure	Lawrence Station	5553
Complete Phosphate	" "	5554
Armour Fertilizer Works, Baltimore, Md.		
Truck and Berry Special	Vineland	5376
Grain Grower	Pennington	5641
High-Grade Potato	Hackensack	5777
Wheat, Corn and Oats Special	Martinville	5743
Fruit and Root Crop Special	Hackensack	5776
Warren Atkinson, Mullica Hill, N. J.		
No. 1 H. G. Potato and Early Truck Fertilizer	Chews Landing	5194
" 2 Potato and General Truck Fertilizer	Glassboro	5219
" 3 Special Sweet Potato Fertilizer	"	5220
" 5 Special Early Tomato Grower	Matawan	5525
" 6 All Around Fertilizer	Chews Landing	5197
James H. Baird, Marlboro, N. J.		
Potato Manure	Marlboro	5067
Asparagus Manure	"	5584
John A. Ballenger, Mullica Hill, N. J.		
H. G. Fertilizer for White Potatoes, Tomatoes, Etc	Mullica Hill	5254
Superior Sweet Potato Phosphate	" "	5255
Baugh and Sons Co., Philadelphia, Pa.		
Special Potato Manure	Pitman	5256
Potato and Truck Special for All Crops	Woodstown	5276
General Crop Grower for All Crops	Camden	5160
The Wrapper Leaf Brand	Elberon	5462
Animal Bone and Potash Compound for All Crops	Stockton	5644
Double Eagle $25 Phosphate	Camden	5161
Complete Animal Bone Fertilizer	Stockton	5643
High-Grade Vegetable Guano	Elberon	5459
Export Bone with Potash	"	5460
The Berg Co., Philadelphia, Pa.		
$35 Potato Manure	Moorestown	5133
Standard Bone Manure	Cologne	5438
* " " "	Skillman	* 5649
$25 Special Bone Manure	"	5648
Vigor Volo Bone and Potash	"	5647

* Duplicate sample.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.		
......	1.28	1.75	3.03	3.28	4.64	1.80	2.00	8.44	10.00	6.44	6.00	11.02	10.00	$26 93	$33 00
0.24	......	2.15	2.39	2.46	7.34	1.96	1.98	11.28	11.00	9.30	9.00	3.14	2.00	20 61	25 00
......	......	2.41	2.41	2.46	6.12	2.44	2.00	10.56	....	8.56	8.00	10.58	10.00	26 39	28 00
......	......	1.63	1.63	1.64	4.58	8.11	2.68	10.37	....	7.69	8.00	2.32	2.00	15 99	26 00
......	......	1.58	1.58	1.64	6.20	2.18	2.00	10.38	9.00	8.38	8.00	10.00	10.00	22 69	36 00
......	......	0.93	0.93	0.82	4.50	8.18	8.09	10.72	....	7.63	7.00	1.56	1.00	12 89	19 00
......	......	1.56	1.56	1.64	5.80	8.19	2.59	11.58	....	8.99	8.00	5.07	5.00	19 21	34 00
0.84	1.04	1.66	3.54	3.69	7.60	2.08	1.21	10.84	11.00	9.63	8.00	7.47	7.00	28 06	33 00
0.68	......	1.74	2.42	2.46	5.82	2.24	1.70	9.26	10.00	7.56	7.00	7.86	7.00	22 91	28 00
......	......	1.52	1.52	1.64	7.50	2.25	1.59	11.34	10.00	9.75	8.00	9.45	10.00	23 06	27 00
2.50	......	1.52	4.02	4.92	7.64	1.28	0.40	9.27	9.00	8.87	8.00	5.73	5.00	27 13	33 50
......	......	1.97	1.97	2.05	4.62	2.55	1.13	8.30	8.00	7.17	7.00	5.16	4.00	18 56	23 00
1.27	1.04	1.07	3.38	3.28	6.16	3.08	1.47	10.71	10.00	9.24	8.00	11.11	10.00	30 27	31 00
3.77	......	2.07	5.84	5.74	8.44	4.88	8.07	11.34	....	8.27	5.00	5.98	5.00	34 23	33 50
0.79	0.98	1.47	3.24	3.28	5.98	8.27	1.87	11.12	....	9.25	8.00	9.06	8.50	28 33	31 50
......	......	1.37	1.37	1.64	6.86	2.31	2.28	11.45	....	9.17	8.00	10.18	9.00	22 88	27 50
......	0.25	1.73	1.98	1.64	4.52	2.09	1.55	8.16	....	6.61	5.00	10.93	10.00	23 14	27 00
1.09	......	1.91	3.00	2.87	6.04	2.34	1.96	10.34	....	8.38	7.00	*6.24	7.00	25 12	29 00
......	......	1.10	1.10	0.82	5.86	2.20	2.16	10.22	....	8.06	8.00	1.50	1.00	13 46	18 00
......	0.88	2.17	3.05	3.28	8.28	1.70	1.84	6.82	....	4.98	3.50	*5.98	5.00	22 11	30 00
......	0.31	1.44	1.75	1.64	6.26	1.86	2.15	10.27	....	8.12	8.00	2.22	2.00	16 48	21 00
......	......	1.66	1.66	1.64	5.40	3.36	2.22	10.98	10.50	8.76	8.00	1.28	1.00	16 00	25 00
......	......	1.70	1.70	1.64	6.04	1.99	2.76	10.79	10.00	8.03	8.00	5.21	5.00	19 05	24 00
......	1.73	2.16	3.89	4.10	5.12	1.40	1.25	7.77	....	6.52	6.00	7.62	7.00	26 81	37 00
......	......	1.83	1.83	1.64	1.40	7.23	5.24	13.87	11.00	8.63	....	2.70	2.00	18 94	30 00
0.74	......	1.40	2.14	2.46	4.42	3.46	3.37	11.25	....	7.88	7.00	12.59	10.00	26 84	30 00
......	......	1.56	1.56	2.46	6.04	2.28	4.60	12.92	....	8.32	8.00	7.48	6.00	21 46	31 40
0.42	......	0.87	1.29	2.46	5.54	2.68	3.09	11.31	....	8.22	8.00	5.96	6.00	18 36	29 00
......	......	1.36	1.36	1.64	5.16	3.65	2.19	11.00	....	8.81	7.00	3.04	3.00	16 42	25 00
0.31	......	1.30	1.61	3.28	3.76	6.48	1.69	11.93	....	10.19	13.00	6.37	5.00	21 13	29 00

* Potash largely, if not entirely, from sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Bowker Fertilizer Co., Boston, Mass.		
Early Potato Manure	Freehold	5089
Potato and Vegetable Fertilizer	Bridgeton	5316
Sure Crop Phosphate	Pittstown	5667
Market Garden Fertilizer	Freehold	5088
Square Brand, Fish and Potash	Plainfield	5745
Stockbridge Manure for Corn, Grain and Fodder Corn	River Edge	5779
Potash—Bone	Paterson	5783
Stockbridge Manure for Potatoes and Vegetables	Red Bank	5501
* " " " "	Hightstown	5601
* " " " "	River Edge	5781
Farm and Garden Phosphate	Westville	5198
Sweet Potato and Truck Manure	Sewell	5221
Hill and Drill Phosphate	Red Bank	5502
Square Brand, Bone and Potash	German Valley	5829
Potato and Vegetable Phosphate	Pennington	5650
Stockbridge Manure for Top Dressing	Paterson	5778
Bradley and Green, Philadelphia, Pa.		
Standard Bone Phosphate for Corn, Wheat and Peas	Freehold	5531
William M. Brown, Cedarville, N. J.		
Special Potato Manure	Cedarville	5339
C. C. Clark and Son, Mt. Ephraim, N. J.		
Truckers' Joy Fertilizer	Mount Ephraim	5164
Special White Potato Fertilizer	" "	5165
Reliable Fertilizer	" "	5166
E. Frank Coe Company, New York City.		
Red Brand Excelsior Guano	Freehold	5090
Alkaline Bone Phosphate	Skillman	5651
Excelsior Guano	Elizabeth	5748
Extra Special Potato Fertilizer	Hightstown	5608
* " " " "	Freehold	5091
Excelsior Potato Fertilizer	Hightstown	5607
Original Ammoniated Dissolved Bone Phosphate	Hackettstown	5819
Peach Tree, Fruit and Grape Vine Fertilizer	Freehold	5098
J. S. Collins and Son, Moorestown, N. J.		
H. G. Fertilizer for Potatoes and General Use	Moorestown	5188
Fish Guano	"	5141
Cabbage and Tomato Fertilizer	"	5139
Truck Guano	"	5142

* Duplicate sample.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.74	......	2.61	3.35	3.28	5.34	1.81	2.11	9.26	8.00	7.15	7.00	7.21	7.00	$25 56	$32 00
0.66	......	1.57	2.23	2.46	7.04	1.88	2.10	10.52	9.00	8.42	8.00	4.12	4.00	19 97	30 00
......	......	0.94	0.94	0.82	6.64	1.76	2.16	10.56	10.00	8.40	9.00	1.79	2.00	15 42	20 00
0.69	......	1.67	2.36	2.46	4.22	1.53	1.88	7.58	7.00	5.75	6.00	10.56	10.00	23 41	32 00
1.05	......	1.40	2.45	2.46	3.50	0.87	1.10	5.47	5.00	4.37	4.00	4.13	4.00	16 63	33 00
0.72	......	2.85	3.57	3.28	2.24	4.44	6.01	12.69	11.00	6.68	10.00	6.71	7.00	27 10	36 00
......	......	1.10	1.10	0.82	4.86	1.31	1.15	7.32	7.00	6.17	6.00	2.66	2.00	12 23	23 50
0.80	......	2.28	3.08	3.28	4.38	1.27	2.60	8.25	7.00	5.65	6.00	9.53	10.00	25 38	35 00
......	1.29	1.75	3.04	3.28	4.92	1.60	1.92	8.44	7.00	6.52	6.00	11.30	10.00	27 24	36 00
......	1.21	1.94	3.15	3.28	3.08	2.45	3.27	8.80	7.00	5.53	6.00	11.39	10.00	27 39	....
0.42	....	1.08	1.50	1.64	6.54	1.98	1.10	9.57	9.00	8.47	8.00	2.14	2.00	15 31	25 00
0.51	......	1.27	1.78	1.64	4.70	2.12	1.39	8.21	8.00	6.82	6.00	8.21	8.00	20 11	30 00
0.50	......	1.87	2.37	2.46	6.48	2.61	2.44	11.53	10.00	9.09	9.00	2.86	2.00	20 21	28 00
......	......	1.49	1.49	1.64	3.48	8.77	4.92	12.17	7.00	7.25	6.00	2.04	2.00	15 73	24 00
0.66	......	1.01	1.67	1.64	4.16	4.48	3.37	11.96	10.00	8.59	9.00	1.85	2.00	16 63	25 00
2.08	......	2.78	4.86	4.92	2.62	3.55	2.74	8.91	6.00	6.17	4.00	7.02	6.00	29 98	....
......	......	2.49	2.49	2.05	6.64	1.27	1.54	9.45	10.00	7.91	8.00	3.17	3.00	19 66	24 00
0.59	......	1.77	2.36	2.46	5.30	1.95	1.62	8.77	....	7.15	7.00	9.95	10.00	24 10	30 00
1.38	......	1.61	2.99	3.28	3.06	4.62	0.76	8.44	8.00	7.68	7.00	8.25	7.00	24 83	30 00
......	......	1.48	1.48	1.64	7.00	0.86	1.00	8.86	9.00	7.86	8.00	10.20	10.00	21 62	27 00
......	....	1.34	1.34	1.64	6.76	1.58	0.85	9.19	9.00	8.34	8.00	1.83	2.00	14 37	23 00
......	1.86	1.57	3.43	3.28	7.28	1.84	1.90	10.52	10.00	8.62	9.00	*7.18	6.00	28 02	35 00
......	......	1.44	1.44	1.23	6.70	1.51	3.09	11.30	10.00	8.21	8.50	*2.73	2.50	16 74	24 00
......	0.77	2.00	2.77	3.28	6.86	1.00	2.52	10.38	10.50	7.86	9.00	*3.70	3.40	21 88	40 00
......	0.45	1.88	1.83	1.64	5.48	1.22	2.98	9.68	9.50	6.70	8.00	*9.08	10.00	22 99	31 00
......	0.58	1.24	1.77	1.64	6.12	1.54	3.27	10.93	10.00	7.66	8.00	*9.92	10.00	24 57	30 00
......	1.08	1.51	2.59	2.46	4.72	1.01	2.91	8.64	9.00	5.73	7.00	*8.44	8.00	24 15	34 00
......	......	1.49	1.49	1.23	6.02	1.63	3.89	11.54	....	7.65	9.00	*2.86	2.25	16 81	25 00
......	0.26	1.48	1.74	1.23	6.96	1.29	1.97	10.22	10.00	8.25	8.00	*5.05	5.00	19 65	28 00
0.78	....	1.64	2.42	2.46	5.46	3.02	1.64	10.12	....	8.48	8.00	*10.07	10.00	26 01	29 00
0.89	......	1.68	2.28	2.46	5.84	2.67	1.55	10.06	....	8.51	8.00	4.39	4.00	20 11	26 00
1.25	......	1.64	2.89	3.28	5.52	2.19	1.19	8.90	....	7.71	7.00	5.36	5.00	22 81	28 00
0.28	......	1.20	1.48	1.64	7.48	1.72	1.44	10.64	....	9.20	8.00	2.55	2.00	16 44	25 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Collins and Pancoast, Merchantville, N. J.		
Extra High-Grade Potato Fertilizer	West Freehold	5094
Cabbage and Tomato Fertilizer	Collingswood	5056
H. G. Fertilizer for Potatoes and General Use	Merchantville	5168
A. A. Cortelyou, Neshanic, N. J.		
Wheat and Rye Special	Neshanic	5702
S. V. Davis, Shiloh, N. J.		
May Queen Fertilizer	Shiloh	5341
B. F. Demaris and Son, Cedarville, N. J.		
Truckers' Pride	Cedarville	5345
Complete No. 1 Bone Phosphate	Shiloh	5347
Truckers' Potato Manure	"	5342
Fish Guano for Sweet Potatoes	Cedarville	5344
Denise and Denise, Freehold, N. J.		
5-8-8 Potato Fertilizer	Adelphia	5095
* " " "	West Freehold	5099
4-8-10 Potato Fertilizer	Jerseyville	5096
* " " "	Howell	5098
Corn Manure	Freehold	5586
6-7-8 Asparagus Fertilizer	Matawan	5585
* " " "	Freehold	5100
Grass Mixture	"	5587
H. W. Doughten, East Moorestown, N. J.		
Special Potato Manure	East Moorestown	5143
Sure Shot Superphosphate	" "	5145
Dried and Ground Fish Guano	" "	5144
James Ewing, Cold Spring, N. J.		
Gilt Edge Potato, Corn and Truck Guano	Cold Spring	5408
J. C. Fifield and Sons Co., Bakersville, N. J.		
Special Potato and Cabbage Manure	Woodbury	5227
Special Sweet Potato Manure	"	5224
Mixture	"	5223
Fish and Potash	Hammonton	5398
Fithian and Pennell, Bridgeton, N. J.		
Complete Phosphate	Bridgeton	5318
James C. Griscom, Woodbury, N. J.		
King Crab Compound	Woodbury	5226

* Duplicate sample.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	......	2.89	2.89	3.28	6.60	2.44	1.15	10.19	....	9.04	8.00	10.27	10.00	$28 02	$30 00
1.22	......	1.86	3.08	3.28	5.24	2.72	1.33	9.29	....	7.96	7.00	5.40	5.00	23 32	28 00
......	......	1.97	1.97	2.46	6.40	2.57	1.44	10.41	....	8.97	8.00	*10.91	10.00	25 78	29 00
......	......	1.67	1.67	1.64	7.96	1.86	1.56	10.88	9.00	9.32	8.00	2.45	2.00	17 27	22 00
......	......	1.70	1.70	1.64	6.22	1.54	1.80	9.56	10.00	7.76	8.00	2.45	2.00	16 07	23 00
2 13	......	1.93	4.06	4.10	5.40	1.83	0.95	8.18	8.00	7.23	7.00	5.32	5.00	26 22	31 00
......	......	1.41	1.41	1.64	6.36	1.80	0.77	8.93	9.00	8.16	8.00	2.21	2.00	14 75	22 00
1.14	......	1.81	2.45	2.46	7.90	1.27	0.38	9.50	10.00	9.17	9.00	5.86	6.00	22 09	30 00
......	......	2.47	2.47	2.46	4.52	2.76	1.38	8.66	8.00	7.28	7.00	3.43	2.50	19 16	24 00
1.05	1.00	1.44	3.49	4.10	6.90	2.17	1.59	10.66	....	9.07	8.00	8.52	8.00	28 44	31 00
1.22	0.90	1.65	3.77	4.10	6.74	1.77	2.57	11.08	....	8.51	8.00	7.58	8.00	28 54	31 00
1.20	......	1.49	2.69	3.28	6.92	2.51	1.59	11.02	....	9.43	8.00	10.01	10.00	27 23	31 00
1.25	......	1.42	2.67	3.28	6.46	1.78	2.59	10.78	....	8.19	8.00	10.08	10.00	26 48	31 00
0.74	......	1.89	2.63	2.46	6.18	8.58	4.56	14.32	....	9.76	10.00	4.59	6.00	24 01	25 00
1.74	0.92	1.05	3.71	4.92	7.16	1.61	1.49	10.26	....	8.77	7.00	6.99	8.00	27 46	34 00
2.18	1.12	1.20	4.45	4.92	7.16	1.26	1.55	9.97	....	8 42	7.00	7.65	8.00	30 50	34 00
6.57	......	*0.91*	*7.48*	*7.58*	*8.76*	*4.52*	*1.19*	*8.47*	....	*8.28*	*6.00*	*3.59*	*3.00*	*36 68*	*36 00*
......	1.21	1.13	2.34	2.46	9.88	1.29	0.45	11.62	....	11.17	10.00	7.63	7.00	25 14	29 00
......	......	2.29	2.29	2.46	9.54	1.58	1.08	12.10	11.00	11.07	10.00	3.04	3.00	21 43	28 00
......	......	3.08	3.08	3.69	3.40	2.60	1.20	7.20	....	6.00	5.85	4.09	3.00	20 76	29 00
1.01	......	1.89	2.90	3.28	4.68	0.49	1.08	6.25	....	5.17	5.00	1.46	1.00	16 74	25 00
......	......	1.90	1.90	2.46	2.16	8.91	1.98	9.03	....	7.10	7.00	9.74	7.00	22 47	35 00
......	......	1.40	1.40	2.05	0.84	5.32	2.22	8.38	....	6.16	5.00	12.08	10.00	21 88	35 00
......	0.63	1.63	2.26	2.46	0.06	6.44	1.82	8.32	....	6.50	5.00	3.72	3.00	17 98	27 00
......	......	1.69	1.69	1.64	2.28	2.46	1.58	6.27	....	6.74	6.00	5.27	4.00	17 41	30 00
0.51	....	*1.24*	*1.75*	*1.84*	*5.26*	*2.47*	*3.47*	*11.20*	*10.00*	*7.73*	*8.00*	*2.00*	*2.00*	*16 37*	*25 00*
1.21	......	2.35	3.56	4.10	6.80	2.06	0.85	9.68	10.00	8.83	8.00	5.70	5.00	25 96	32 00

*Potash largely, if not entirely, from sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Hendrickson and Dilatush, Robbinsville, N. J.		
High-Grade Potato Manure	Plainsboro	5072
Corn and Truck Manure	"	5071
Truckers' High-Grade Manure	Robbinsville	5614
Dissolved Bone and Potash	"	5615
Special Potato Manure	Plainsboro	5073
Alkaline Bone	"	5074
Farmers' Friend	Robbinsville	5613
S. M. Hess and Bro., Philadelphia, Pa.		
Special Potato Manure	Freehold	5102
Keystone Bone Phosphate	Toms River	5470
Special Corn Manure	Freehold	5101
Potato and Truck Manure	Ringoes	5668
Sweet Potato Manure	Toms River	5472
Fish and Potash Manure	"	5474
Jacob V. Higgins, Flemington, N. J.		
Golden Rod	Flemington	5704
Ira Hill, Copper Hill, N. J.		
Pure Bone Fertilizer	Copper Hill	5706
Potato Fertilizer	" "	5707
Top Dressing	" "	5708
Hill and Co., Flemington, N. J.		
Standard Fertilizer	Flemington	5709
Hires and Co., Quinton, N. J.		
Potato and Tomato Phosphate	Quinton	5300
Standard Bone Superphosphate for General Use	"	5299
Special Wheat and Oats Phosphate	"	5298
Barton Hoffman, Ringoes, N. J.		
General Use Fertilizer	Ringoes	5670
P. Hoffman and Bro., Raubsville, Pa.		
Potato Fertilizer	Phillipsburg	5669
The Hubbard Fertilizer Co., Baltimore, Md.		
Truckers' Five Per Cent. Royal Seal Compound	Gloucester	5200
International Seed Co., Rochester, N. Y.		
Potato and Truck Manure	Collingswood	5057
Grain and Grass Fertilizer	Ridgewood	5785
A1 Special Manure	Shiloh	5850
Keystone Chemical Fertilizer Co., Philadelphia, Pa.		
Potato and Tomato Manure	Vineland	5878
Harvest Queen	"	5881

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.74	......	2.47	3.21	3.28	5.82	2.28	1.29	9.34	10.00	8.05	8.00	10.46	10.00	$28 31	$33 00
......	......	1.94	1.94	1.64	4.58	2.43	4.35	11.36	9.00	7.01	7.00	4.15	4.00	18 76	25 00
1.98	......	*2.14*	*4.07*	*4.10*	*4.60*	*2.79*	*1.45*	*8.84*	*10.00*	*7.39*	*8.00*	*9.22*	*8.00*	*29 53*	*35 00*
1.12	......	1.62	2.74	1.64	5.12	2.58	2.65	10.30	10.00	7.65	8.00	5.08	4.50	22 06	25 00
0.46	......	1.58	1.99	2.46	7.62	2.21	1.29	11.12	10.00	9.83	8.00	9.71	10.00	24 84	30 00
......	......	1.73	1.73	0.63	4.00	4.37	4.28	12.65	11.00	8.37	9.00	2.95	1.50	18 15	20 00
1.07	......	*2.05*	*3.12*	*2.46*	*4.86*	*3.38*	*2.61*	*10.85*	*9.00*	*8.24*	*7.00*	*4.98*	*4.00*	*23 91*	*28 00*
0.65	0.33	2.03	3.01	3.28	6.76	1.31	1.12	9.19	....	8.07	8.00	7.56	7.00	25 01	32 00
......	......	1.21	1.21	0.82	7.24	1.10	3.66	12.00	10.00	8.34	8.00	1.53	1.00	14 75	22 00
......	......	*1.01*	*1.01*	*0.82*	*6.50*	*1.72*	*2.18*	*10.40*	*9.00*	*8.22*	*8.00*	*1.79*	*2.00*	*13 55*	*23 00*
0.59	......	1.86	2.45	2.46	7.06	1.89	1.91	10.86	9.00	8.95	8.00	6.01	6.00	22 81	30 00
......	0.26	1.38	1.64	1.64	6.64	1.26	1.17	9.07	9.00	7.90	8.00	10.14	10.00	22 22	23 00
0.33	......	1.21	1.54	1.64	5.40	2.47	1.68	9.50	....	7.87	8.00	3.33	3.00	16 16	28 00
0.18	......	0.79	0.97	1.23	7.78	1.74	0.96	10.48	....	9.52	8.00	3.35	4.00	15 34	20 00
......	......	2.24	2.24	2.05	2.60	4.45	1.41	8.46	....	7.05	10.50	3.33	2.50	18 01	23 00
0.48	......	2.31	2.79	2.46	2.66	5.45	1.23	9.34	....	8.11	9.00	8.40	8.00	25 11	28 00
7.58	......	1.37	8.95	9.84	0.00	3.17	0.96	4.13	....	3.17	6.00	8.10	7.00	40 98	44 00
......	......	1.72	1.72	1.64	6.96	1.59	3.10	11.65	9.00	8.55	8.00	3.22	3.00	18 03	23 00
0.56	......	1.65	2.21	2.46	5.90	1.85	1.59	9.34	9.00	7.75	8.00	6.06	5.00	20 77	23 00
0.47	......	1.08	1.55	1.64	5.80	2.33	1.67	9.30	9.00	7.63	8.00	2.91	3.00	15 61	20 00
......	......	0.90	0.93	0.82	4.44	3.60	2.10	10.14	9.00	8.04	8.00	2.31	2.00	13 37	16 00
......	......	0.98	0.93	0.82	7.10	1.42	1.25	9.77	....	8.52	8.00	2.07	2.00	13 37	20 00
......	......	1.70	1.70	2.46	5.12	2.94	1.32	9.38	10.00	8.06	7.00	4.69	6.00	18 06	32 00
1.29	1.43	1.15	3.87	4.10	5.54	1.33	1.09	7.96	....	6.87	6.00	5.01	5.00	24 54	32 50
0.32	......	0.91	1.23	1.23	5.50	2.34	1.82	9.66	9.00	7.84	8.00	7.33	7.00	18 48	29 00
......	......	1.68	1.63	1.64	7.14	2.80	2.58	12.47	11.00	9.94	10.00	2.73	2.00	18 31	26 00
0.65	0.20	1.24	2.09	2.46	4.10	1.71	1.55	7.36	7.00	5.81	6.00	9.06	10.00	21 05	....
......	......	1.61	1.61	1.64	5.52	2.86	1.63	9.51	....	7.88	8.00	7.90	12.00	19 82	23 50
......	......	0.91	0.91	0.82	7.90	2.47	0.58	10.95	....	10.37	10.00	3.96	4.00	16 50	22 50

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Keystone Chemical Fertilizer Co.—(Cont.)		
Peerless Potato Fertilizer	Vineland	5379
Garden Special Fertilizer	"	5380
Hervey Kuhl, Flemington, N. J.		
Bone and Potash	Flemington	5710
Ammoniated Dissolved Bone	"	5711
Lambertson and Hance, Freehold, N. J.		
High-Grade Potato Fertilizer	West Freehold	5110
Standard Potato Fertilizer	" "	5111
Asparagus Fertilizer	Freehold	5107
Complete Fertilizer	"	5105
Potato and Truck Fertilizer	"	5106
Corn Manure	"	5592
Grass Mixture	"	5593
C. A. Lippincott and Bro., Moorestown, N. J.		
H. G. Fertilizer for Potatoes and General Use	Moorestown	5146
Lister's Agricultural Chemical Works, Newark, N. J.		
Freehold Special for Potatoes	Freehold	5112
Special Ten Per Cent. Potato	Red Bank	5518
Potato Manure	Matawan	5508
Ammoniated Dissolved Bone Phosphate	Lawrence Station	5557
Standard Pure Bone Superphosphate of Lime	Red Bank	5512
Corn Fertilizer No. 2	Skillman	5655
Mount Rose Corn Fertilizer	Pennington	5656
Corn and Potato Fertilizer	Madison	5762
U. S. Superphosphate	Middlebush	5759
Special Corn Fertilizer	Passaic	5791
Fruit and Vine Fertilizer	Matawan	5509
Potato Fertilizer No. 2	"	5510
Ten Per Cent. Potato Fertilizer	Lawrence Station	5558
"G" Brand	Skillman	5654
Special Crop Producer	Ringoes	5672
Success Fertilizer	Pittstown	5678
3-6-10 for Potatoes	Madison	5763
Frederick Ludlam Co., New York City.		
Potato Grower	Adelphia	5116
Cecrops, or Dragon's Tooth Brand	"	5115
The Mapes Formula and Peruvian Guano Co., N. Y. City.		
Corn Manure	Camden	5175

Complete Fertilisers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
1.45	......	1.28	2.73	3.28	5.24	2.16	1.98	9.38	....	7.40	7.00	8.56	9.00	$24 39	$33 00
0.85	......	0.78	1.63	1.64	4.44	2.60	1.72	8.76	....	7.04	6.00	8.04	8.00	19 64	29 00
0.34	......	0.50	0.84	0.82	5.86	1.96	2.72	10.54	10.00	7.82	8.00	1.10	1.00	12 08	19 00
0.56	......	1.13	1.69	1.64	4.56	2.94	3.38	10.88	10.00	7.50	8.00	1.98	2.00	15 86	24 00
1.74	......	2.43	4.17	4.10	4.80	2.59	1.85	9.24	....	7.39	8.00	9.14	8.00	30 07	31 00
1.52	......	1.78	3.30	3.28	4.40	3.79	2.47	10.66	....	8.19	8.00	10.75	10.00	29 26	31 00
2.64	......	3.30	5.94	5.74	3.64	2.75	2.38	8.77	....	6.39	6.00	6.28	5.00	33 24	33 00
0.75	......	1.96	2.71	3.28	6.44	2.44	2.63	11.51	....	8.88	8.00	7.54	7.00	25 25	28 00
1.40	......	2.17	3.57	3.69	5.36	2.32	2.16	9.84	10.00	7.68	....	8.39	7.50	27 69	30 00
0.87	......	1.38	2.25	2.46	7.44	3.13	2.08	12.60	....	10.57	10.00	5.31	5.00	22 90	25 00
6.05	......	0.99	7.04	7.38	3.44	5.00	0.70	9.14	....	8.44	6.00	5.89	5.00	37 12	38 00
0.77	0.98	1.29	3.04	3.28	7.52	0.62	1.62	9.76	....	8.14	8.00	8.03	7.00	25 63	30 00
......	0.96	2.21	3.17	3.28	3.84	2.22	2.38	8.44	....	6.06	6.00	10.52	10.00	26 88	30 00
......	......	1.78	1.78	1.64	6.72	1.64	2.64	11.00	....	8.36	8.00	10.52	10.00	24 11	30 00
1.19	0.67	1.24	3.10	3.28	6.50	2.08	1.82	10.35	9.00	8.53	8.00	7.21	7.00	25 53	34 00
......	......	2.17	2.17	2.05	4.08	3.55	3.61	11.24	9.00	7.63	8.00	1.77	1.50	17 85	22 00
......	0.49	1.82	2.31	2.46	7.34	1.99	2.74	12.07	11.00	9.33	9.00	2.02	2.00	19 66	28 00
......	0.19	1.35	1.54	1.64	8.88	1.62	2.14	12.64	....	10.50	10.00	3.85	4.00	19 25	25 00
......	......	1.69	1.69	1.64	5.68	2.54	2.32	10.54	10.00	8.22	8.00	1.96	1.50	16 25	24 00
......	......	1.67	1.67	1.64	5.80	2.19	3.55	11.54	9.00	7.99	8.00	3.07	3.00	17 40	†19 45
......	......	1.07	1.07	1.03	6.22	1.75	2.28	10.20	10.00	7.97	8.00	2.13	2.00	13 83	21 00
......	......	1.47	1.47	1.64	6.18	2.08	2.68	10.94	9.00	8.26	8.00	3.07	3.00	16 55	24 00
......	......	1.73	1.73	1.64	4.88	3.23	2.19	10.30	8.00	8.11	....	6.80	7.00	20 36	34 00
......	......	1.66	1.66	1.64	8.14	2.58	2.83	13.00	11.00	10.67	10.00	4.10	4.00	20 16	30 00
......	1.99	0.63	2.62	2.46	7.64	2.20	1.00	10.84	....	9.84	10.00	*9.98	10.00	28 28	33 00
......	......	0.94	0.94	0.82	7.66	1.80	1.07	10.55	10.00	9.46	8.00	3.65	4.00	15 52	21 00
......	......	1.03	1.03	0.82	6.36	1.17	1.47	8.00	8.00	6.53	7.00	1.30	1.00	11 39	18 00
......	......	1.26	1.26	1.23	7.16	2.14	2.31	11.61	11.00	9.30	9.00	1.85	2.00	15 52	21 00
0.27	0.52	1.61	2.40	2.46	5.08	1.94	1.72	8.74	....	7.02	6.00	*10.26	10.00	24 68	†26 70
1.15	0.73	1.33	3.21	3.28	5.62	2.75	2.66	11.03	10.00	8.37	9.00	10.10	10.00	28 57	33 00
0.99	......	2.42	3.41	3.28	4.84	1.61	1.49	7.94	....	6.45	7.00	6.98	7.00	24 66	30 50
1.17	0.82	0.97	2.46	2.46	3.52	5.39	2.57	11.48	10.00	8.91	8.00	6.62	6.00	23 57	36 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
The Mapes Formula and Peruvian Guano Co.—(Con)		
Vegetable Manure, or Complete Manure for Light Soils	Hammonton	5400
Economical Potato Manure	Bridgeton	5319
Complete Manure for Heavy Soils	Matawan	5589
Top Dresser Improved—Full Strength	Rio Grande	5410
Complete Manure for Average Soils	Matawan	5540
" " " General Use	Westwood	5793
Potato Manure	German Valley	5830
General Crop Brand	Newton	5806
Cauliflower and Cabbage Manure	Camden	5179
Fruit and Vine Manure	Hammonton	5401
Complete Manure, Ten Per Cent Potash	"	5402
Top Dresser Improved—Half Strength	Morristown	5810
Lawn Top Dressing	Newark	5764
Grass and Grain Spring Top Dressing	Morristown	5811
Cereal Brand	Hamburg	5821
Ammoniated Dissolved Bone with Potash	German Valley	5831
Michigan Carbon Works, Detroit, Mich.		
Homestead Corn and Grain Producer	Plainsboro	5561
" H. G. Blood, Bone and Potash Fertilizer	Hightstown	5618
* " " " " " "	Plainsboro	5559
" "A" Bone Black Fertilizer	"	5560
John E. Minch, Bridgeton, N. J.		
Complete Phosphate	Bridgeton	5824
Sweet Potato Manure	"	5826
Grain and Grass Grower	"	5825
Minch Bros., Bridgeton, N. J.		
Complete Fertilizer	Bridgeton	5822
J. R. Moore, Swedesboro, N. J.		
Gilt Edge Sweet Potato Manure	Swedesboro	5279
Early Tomato Guano	"	5280
Baxter Tomato Guano	"	5278
Edmund Mortimer and Co., New York City.		
Genuine Imported Peruvian Guano	Mullica Hill	5280
† Peruvian Guano	Woodbridge	5594
* " "	New Brunswick	5216
Muzzy Bros., Paterson, N. J.		
Potato and Truck Special	Paterson	5795
Sure Fertilizer for General Crops	"	5796

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
4.76	0.29	0.84	5.89	4.92	8.30	3.64	2.06	9.00	8.00	6.94	6.00	*8.65	6.00	$35 87	$44 00
2.57	0.26	0.49	3.32	3.28	2.06	2.52	2.32	6.90	6.00	4.58	4.00	*9.71	8.00	25 95	36 00
3.17	0.47	1.31	4.95	4.92	3.70	2.61	4.23	10.54	10.00	6.31	8.00	*4.18	3.00	28 62	41 00
8.92	0.27	0.24	9.43	9.84	2.08	3.86	2.78	8.72	8.00	5.94	....	5.03	4.00	42 91	51 00
3.67	0.19	0.39	4.25	4.10	4.40	3.47	2.20	10.07	8.00	7.87	7.00	*6.31	5.00	28 86	37 00
2.88	0.37	0.52	3.27	3.28	2.12	4.68	4.60	11.40	10.00	6.80	8.00	3.95	4.00	22 64	38 00
2.76	0.40	0.49	3.65	3.69	3.42	4.14	3.18	10.74	8.00	7.56	8.00	*7.13	6.00	27 79	38 00
0.51	0.36	0.87	1.74	1.64	3.24	4.42	3.59	11.25	10.00	7.66	8.00	2.40	2.00	16 58	27 00
3.24	0.28	0.67	4.19	4.10	2.40	4.04	1.46	7.90	....	6.44	6.00	7.06	6.00	26 86	39 00
1.28	0.31	0.29	1.88	1.64	1.84	3.80	2.70	8.34	7.00	5.64	5.00	*11.21	10.00	23 60	42 00
1.41	0.41	0.42	2.24	2.05	1.50	2.99	2.43	6.92	5.00	4.49	3.00	9.73	10.00	21 06	34 00
4.80	......	......	4.80	4.92	0.52	1.52	2.81	4.85	4.00	2.04	....	*3.17	2.00	22 45	34 00
1.85	......	0.17	2.02	2.46	0.80	2.06	1.51	4.37	3.50	2.86	....	2.48	2.50	12 20	30 00
3.88	0.27	0.69	4.84	4.92	1.52	4.07	2.62	8.21	6.00	5.59	5.00	7.76	7.00	29 38	42 00
0.92	0.31	0.55	1.78	1.64	2.40	4.09	3.01	9.50	8.00	6.49	6.00	3.40	3.00	16 19	30 00
0.25	0.43	0.73	1.41	1.23	5.16	4.53	3.08	12.77	12.00	9.69	10.00	2.01	1.50	16 72	28 00
......	......	1.79	1.79	1.64	7.10	1.08	1.52	9.70	9.00	8.18	8.00	2.45	2.00	16 67	17 75
0.51	1.09	1.44	3.04	3.28	6.16	1.23	0.42	7.81	7.00	7.39	6.00	9.53	10.00	25 80	30 00
......	1.45	1.72	3.17	3.28	5.16	1.90	0.90	7.96	7.00	7.06	6.00	11.34	10.00	27 79	....
......	......	1.79	1.79	2.05	7.20	1.61	2.14	10.95	9.00	8.81	8.00	1.55	1.50	16 73	18 55
0.49	.....	1.51	2.00	2.05	6.84	1.54	1.54	9.92	....	8.38	8.00	4.40	4.00	19 16	25 00
0.50	......	1.11	1.61	1.64	5.08	2.67	1.74	9.49	....	7.75	8.00	9.42	10.00	21 49	29 00
0.25	......	0.50	0.75	0.82	5.76	2.74	1.42	9.92	....	8.50	8.00	2.06	2.00	12 67	18 00
......	0.22	1.53	1.75	1.64	5.86	2.51	2.61	10.98	....	8.37	8.00	2.27	2.00	16 93	21 50
0.25	......	1.11	1.36	1.64	6.86	1.91	1.61	10.38	9.00	8.77	8.00	*10.53	10.00	24 02	28 00
2.40	......	2.73	5.13	5.74	4.78	1.63	0.97	7.38	7.00	6.41	6.00	5.04	5.00	28 70	35 00
1.15	......	2.23	3.38	3.69	3.84	3.02	1.59	8.45	....	6.86	7.00	3.09	3.00	21 60	27 00
......	3.98	3.99	7.97	6.31	2.64	6.29	1.73	10.66	9.00	8.93	7.50	2.14	2.00	39 24	42 00
0.25	1.87	0.77	2.89	2.68	2.36	6.38	10.15	18.89	18.00	8.74	....	3.30	3.50	24 99	30 00
0.19	1.85	0.91	2.95	2.68	2.60	9.04	10.36	22.00	18.50	11.64	....	3.90	3.50	28 44	30 00
......	1.15	1.69	2.84	2.87	6.30	1.49	2.08	9.87	....	7.79	7.00	7.26	7.00	24 29	32 00
......	1.12	1.73	2.85	2.87	6.24	1.90	1.96	10.10	....	8.14	7.00	*7.19	7.00	24 75	32 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Nassau Fertilizer Co., New York City.		
Success Fertilizer, General Favorite	Pittstown	5675
O. H. Dilts' Special Compound for all Crops	Ringoes	5677
" Special for Potatoes	"	5678
" Corn Fertilizer	"	5679
Albert Nelson and Co., Allentown, N. J.		
"B" Brand Special Potato Manure	West Freehold	5119
Special Potato Manure	Marlboro	5118
James E. Otis, Tuckerton, N. J.		
Special for Potatoes	Cologne	5443
Menhaden Fish Guano	Egg Harbor	5444
S. L. Pancoast, Mullica Hill, N. J.		
High-Grade Early Potato Grower	Mullica Hill	5259
XX Special H. G. Early Potato Grower	" "	5260
Early Truck Fertilizer	" "	5261
*"S" Special Sweet Potato Grower	" "	5394
Peterson and Smith, Woodstown, N. J.		
High-Grade Potato Fertilizer	Woodstown	5281
Potato Superphosphate	"	5283
Wheat and Oat Superphosphate	"	5282
John Repp, Glassboro, N. J.		
High-Grade White Potato Fertilizer	Glassboro	5263
High-Grade Fertilizer	"	5262
Edward Rigg, Jr., Burlington, N. J.		
Potato Manure	Burlington	5151
Grass and Grain Grower	"	5152
Fish Guano	"	5153
M. F. Riley, Elmer, N. J.		
Potato and Truck	Elmer	5854
High-Grade Potato Manure	"	5855
Early Potato Manure	"	5853
C. W. Saul, Rio Grande, N. J.		
Anti-Trust Special	Rio Grande	5415
" " Potato and Tomato Guano	" "	5416
Scott Fertilizer Co. Elkton, Md.		
Schooley's Sweet Potato Grower	Swedesboro	5287
" Tomato Grower	"	5286
Sharpless & Bro., Camden, N. J.		
Extra High-Grade Potato Manure	Camden	5182
No. 1 for General Use	"	[illegible]

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumer's Depot.
......	......	0.82	0.82	0.82	6.66	2.01	2.68	11.30	9.00	8.67	8.00	4.06	4.00	$15 33	$21 00
......	......	0.98	0.93	0.82	3.68	2.86	3.08	9.57	8.00	6.54	7.00	5.77	5.00	15 44	22 00
......	......	1.13	1.13	0.82	6.76	1.95	1.82	10.53	9.00	8.71	8.00	6.25	7.00	18 06	26 00
......	......	1.06	1.06	1.03	3.80	3.38	2.83	10.01	8.00	7.18	7.00	1.67	1.50	12 93	18 00
1.38	......	1.78	3.16	3.28	6.22	2.15	1.16	9.53	....	8.37	6.00	11.06	10.00	28 72	35 00
0.84	......	0.82	1.66	1.64	7.82	1.89	1.27	10.48	....	9.21	8.00	10.86	10.00	23 93	30 00
.....	......	2.17	2.17	1.64	5.60	1.68	1.52	8.80	8.00	7.28	....	9.83	10.50	23 55	28 00
......	......	2.45	2.45	3.28	6.16	2.20	1.42	9.78	7.00	8.36	....	6.25	5.00	22 46	28 00
0.93	......	2.15	3.08	3.28	6.60	1.08	1.04	8.72	....	7.68	7.00	8.27	7.00	25 48	29 50
1.83	......	1.57	3.40	3.69	7.00	1.56	1.55	10.11	....	8.56	9.00	8.65	7.50	27 19	32 00
0.75	......	1.56	2.31	2.67	6.92	2.25	1.70	10.87	....	9 17	8.00	5.35	5.00	21 80	27 00
0.20	......	1.67	1.87	1.85	6.62	1.36	1.09	9.07	....	7.98	8.00	*11.44	9.50	25 66	28 00
1.06	......	2.05	3.11	3.28	4.16	3.86	2.68	10.20	10.00	7.52	8.00	8.35	8.00	28 12	30 00
......	0.24	1.86	2.10	2.46	3.60	2.17	1.28	7.05	8.00	5.77	6.00	10.76	10.00	22 57	28 00
0.27	......	0.67	0.94	0.82	5.10	3.47	1.50	10.07	10.00	8.57	8.00	2.11	2.00	13 58	18 00
......	......	2.44	2.44	2.87	7.10	1.46	0.89	9.45	9.00	8.56	8.00	10.50	10.00	26 02	30 00
......	0.98	0.99	1.97	2.05	5.60	1.78	1.14	8.52	9.00	7.38	8.00	10.00	10.00	22 70	27 00
0.42	......	1.09	1.51	1.64	6.04	1.69	1.77	9.50	....	7.73	8.00	10.94	10.00	22 43	27 00
0.60	......	0.86	1.46	1.23	5.86	2.98	1.79	10.13	....	8.34	8.00	2.14	2.00	15 27	19 00
0.78	......	1.37	2.15	2.46	4.88	2.22	1.47	8.57	....	7.10	7.00	5.29	5.00	19 05	26 00
......	.....	1.66	1.66	1.64	2.88	4.85	5.04	12.27	....	7.23	8.00	5.23	5.00	19 12	25 00
0.80	......	1.67	2.47	2.46	2.72	3.96	3.11	9.79	....	6.68	7.00	8.41	8.00	25 30	27 00
1.36	......	1.70	3.06	3.28	1.66	4.24	3.38	9.28	....	5.90	6.00	10.54	8.00	26 53	30 00
0.41	......	1.12	1.53	1.64	6.00	1.98	1.50	9.48	....	7.98	8.00	9.80	10.00	21 64	28 00
0.58	0.81	1.41	2.30	2.46	4.88	1.57	1.78	8.23	....	6.45	7.00	6.37	7.00	20 20	28 50
......	......	1.49	1.49	1.64	5.86	2.26	1.70	9.82	....	8.12	6.00	10.25	10.00	22 20	....
......	0.95	1.31	2.26	2.46	3.68	4.49	2.06	10.23	....	8.17	6.00	6.99	6.00	21 44	....
1.14	......	2.05	3.19	3.28	4.66	1.96	2.20	8.83	....	6.63	6.00	10.19	10.00	26 97	32 00
1.15	......	0.51	1.66	1.64	6.32	1.96	1.55	9.82	....	8.27	8.00	3.70	3.00	17 01	23 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Sharpless & Bro.—(Cont.)		
Ten Per Cent. Truck Guano	Camden	5180
Seven Per Cent. Special Truck Guano	"	5181
J. E. Sherman, Frenchtown, N. J.		
Corn Manure	Frenchtown	5685
M. L. Shoemaker & Co., Philadelphia, Pa.		
Swift-Sure Superphosphate for Potatoes	Moorestown	5059
" " " General Use	Quinton	5302
" Guano for Tomatoes, Truck and Corn	Egg Harbor	5449
" Special Ten Per Cent. Potato Fertilizer, No. 2	Westville	5209
" " " " " " No. 1	Moorestown	5149
Good Enough Superphosphate	Rio Grande	5418
Lester Shurts, Neshanic Station, N. J.		
Standard Bone Phosphate	Neshanic Station	5718
Joseph Smith & Co., Stockton, N. J.		
Prallsville Formula for Corn and Potatoes	Stockton	5668
Rufus W. Smith, Elmer, N. J.		
Highest-Grade Truck Manure	Elmer	5358
The Best Sweet Potato Manure	"	5357
Trucker Fertilizer	"	5360
General Purpose Fertilizer	"	5361
Taylor Bros., Camden, N. J.		
High-Grade Potato Phosphate	Vineland	5391
Animal Bone Phosphate	Camden	5174
Taylor Provision Co., Trenton, N. J.		
High-Grade Potato and Truck Fertilizer	Marlboro	5097
" " Corn and Truck Manure	Hammonton	5406
Special Potato Fertilizer	"	5405
I. P. Thomas & Son Co., Philadelphia, Pa.		
Truckers' High-Grade Guano	Salem	5245
* " " " "	Sewell	5229
Marter's Fish Mixture	Cedarville	5364
Farmers' Choice Bone Phosphate	Roselle	5753
High-Grade Potato Manure	Cedarville	5365
* " " " "	Lawrence Station	5562
*‡ " " " "	Vineland	5640
Special Potato Manure	Salem	5246
Thomas' Wheat and Corn Fertilizer	Lawrence Station	5564
Vegetable Manure	White House	5733
Normal Bone Phosphate	" "	5734

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumer's Depot.
1.84	3.08	3.16	7.53	8.20	3.86	1.44	0.93	6.23	....	5.30	4.00	5.25	4.08	$36 63	$45 00
1.68	2.04	1.84	5.56	5.74	4.58	1.34	0.90	6.82	....	5.92	5.00	10.00	9.60	33 85	38 00
1.23	......	1.00	2.23	1.64	1.39	6.16	4.21	11.75	....	7.54	8.00	6.76	7.00	21 25	25 00
0.82	.....	1.99	2.81	2.87	7.10	3.38	2.22	12.70	11.00	10.48	8.00	7.97	7.00	27 25	†28 50
0.97	......	1.80	2.77	2.87	6.96	3.76	3.21	13.93	14.00	10.72	9.00	4.84	4.50	25 00	31 00
0.68	......	1.15	1.83	1.64	6.80	2.38	2.50	11.68	....	9.18	8.00	5.36	5.00	20 39	27 50
0.78	......	1.14	1.87	1.64	6.26	2.89	2.50	11.15	....	8.65	8.00	10.71	10.00	24 58	29 00
1.78	......	1.07	2.85	3.28	4.70	3.49	2.07	10.26	....	8.19	6.00	10.45	10.00	27 09	31 00
0.72	......	1.11	1.83	1.64	7.60	2.61	1.94	12.15	12.00	10.21	8.00	2.81	2.00	18 95	20 00
......	......	0.91	0.91	0.82	6.42	1.52	2.76	10.70	9.00	7.94	8.00	4.03	4.00	15 05	21 00
0.33	......	1.62	1.95	2.05	7.16	1.88	1.95	10.99	9.00	9.04	8.00	6.47	6.00	21 53	26 00
0.75	0.20	2.61	3.56	3.69	4.82	2.11	1.51	8.44	8.00	6.93	6.00	*6.70	6.50	26 08	30 00
0.44	......	1.29	1.73	1.64	5.84	2.03	1.47	9.34	....	7.87	8.00	9.44	10.00	21 93	27 50
0.57	.....	1.58	2.15	2.46	4.98	1.65	1.43	8.06	....	6.63	7.00	9.13	8.00	22 09	27 50
0.32	......	1.15	1.47	1.64	6.40	1.70	2.05	10.15	10.00	8.10	8.00	*5.74	5.00	18 57	23 00
......	0.36	1.58	1.94	1.64	3.78	2.01	2.15	7.94	....	5.79	5.00	10.90	10.00	22 45	30 00
......	......	1.82	1.82	1.64	5.42	2.94	2.59	10.95	....	8.36	8.00	1.42	1.00	16 50	21 00
1.44	......	1.77	3.21	3.28	6.10	2.14	1.71	9.95	....	8.24	8.00	11.10	10.00	28 99	32 00
0.70	.....	1.81	2.01	2.46	8.46	2.06	2.72	13.24	....	10.52	8.00	5.04	5.00	22 07	28 50
0.88	......	1.19	2.07	2.05	5.92	2.92	2.14	10.98	....	8.84	8.00	12.45	10.00	26 79	30 00
0.60	.....	1.86	2.46	3.28	3.82	4.02	0.58	8.42	8.00	7.84	7.00	8.86	7.00	25 74	30 00
0.91	......	1.81	2.72	3.28	6.24	1.16	1.86	8.76	8.00	7.40	7.00	8.07	7.00	23 86	33 00
......	0.22	4.11	4.33	4.31	3.24	1.64	1.77	6.65	....	4.88	5.00	2.48	1.25	23 19	30 00
......	......	1.06	1.06	1.64	5.16	5.30	1.14	11.60	10.50	10.46	9.50	2.69	2.00	16 08	25 00
0.93	......	0.81	1.77	2.46	6.74	1.62	0.84	9.20	9.00	8.36	8.00	9.98	10.00	22 60	30 00
1.04	......	0.67	1.71	2.46	7.48	0.75	1.04	9.27	9.00	8.23	8.00	9.15	10.00	21 63	31 00
0.92	......	1.55	2.47	2.46	5.72	3.26	0.82	9.80	9.00	8.98	8.00	10.94	10.00	25 58	31 00
......	......	1.47	1.47	1.64	6.66	1.08	1.28	9.02	8.00	7.74	7.00	10.08	10.00	21 50	27 00
0.30	......	0.88	1.18	0.82	4.80	3.38	1.13	9.31	10.00	8.18	9.00	3.50	3.00	15 07	22 00
0.49	......	0.59	1.08	1.64	7.42	1.92	1.89	10.73	....	9.34	8.00	4.28	4.00	16 45	25 00
......	......	1.00	1.00	1.07	6.16	2.30	1.10	9.56	9.50	8.46	8.50	1.57	1.50	15 09	23 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Trenton Bone Fertilizer Co., Trenton, N. J.		
$32 Potato Manure	Marlboro	5120
Special Potato Manure	Cranbury	5077
" Corn Manure	Matawan	5544
Corn and Truck Fertilizer	Hyson	5187
Tomato and Truck Fertilizer	Martinville	5754
High-Grade Potato Fertilizer	Hightstown	5622
* " " " "	Matawan	5546
Potato Manure	Hightstown	5624
* " "	Matawan	5545
Excelsior	Egg Harbor	5453
Stults' Special for Wheat and Grass	Pleasantville	5486
Corn Mixture	Pennington	5664
F. W. Tunnell & Co., Philadelphia, Pa.		
Potato and Grain Manure	Edgewater Park	5020
Sweet and White Potato Manure	Beverly	5022
Truckers' High-Grade Fish Guano	"	5023
* " " " " "	Bridgeton	5830
Hilton Brand	Moorestown	5061
Special Potato Manure No. 1	West Freehold	5121
High-Grade Truck and Potato Manure	Woodstown	5291
XX Ten Per Cent. Sweet Potato Manure	Edgewater Park	5021
Royal Fish Guano	Bridgeton	5832
No. 1 Special High-Grade Potato Manure	Monmouth Junction	5080
† Special Ammoniated Bone and Potash	Bridgeton	5833
* " " " " "	"	5841
* " " " " "	White House	5738
Early Truck and Potato Manure	Beverly	5024
Raw and Dissolved Bone and Muriate of Potash	Princeton Junction	5081
Tomato Guano	Pitman	5271
Fish Guano for All Crops	Salem	5247
Special Dissolved Bone Compound	"	5248
Complete Superphosphate	Pitman	5269
Special High-Grade Potato Manure	Titusville	5567
* " " " " "	Woodstown	5292
Potato Manure	Titusville	5568
Potato and Grain with 400 lbs. Potash	"	5571
Royal Wheat Grower	"	5574
Royal Bone Mixture	Ringoes	5724

* Duplicate sample. † .laimed by dea er had been wet and was not representative.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumer's Depot.
0.61	....	1.92	2.52	2.46	6.44	2.44	1.76	10.64	....	8.88	8.00	10.30	10.00	$26 59	$32 00
1.36	....	1.53	2.89	3.28	5.54	2.47	3.30	11.31	....	8.01	8.00	10.87	10.00	28 05	35 00
0.22	.....	1.46	1.68	1.64	2.78	5.50	3.64	11.92	....	8.28	8.00	3.49	3.00	18 03	25 00
0.56	.....	1.81	2.37	2.46	3.76	6.20	3.95	13.91	....	9.96	10.00	4.69	5.00	23 13	34 00
......	.....	1.62	1.62	1.64	2.78	4.37	5.18	12.33	....	7.15	8.00	5.14	5.00	18 96	27 00
1.08	.....	1.83	2.91	3.28	1.46	3.82	4.36	9.64	....	5.28	6.00	10.15	10.00	25 56	34 00
1.32	.....	1.83	3.15	3.28	2.28	3.80	4.40	10.48	....	6.08	6.00	10.60	10.00	27 53	....
0.47	.....	1.36	1.83	1.64	1.44	5.64	4.40	11.48	....	7.08	8.00	6.15	7.00	19 99	27 00
0.95	.....	0.80	1.75	1.64	1.72	4.81	3.79	10.32	....	6.53	8.00	7.01	7.00	19 55	....
......	.....	1.13	1.13	0.82	1.40	6.83	3.63	11.86	....	8.23	8.00	2.34	2.00	15 03	22 00
......	.....	2.57	2.57	2.05	1.20	10.18	5.06	16.44	....	11.38	11.00	10.09	10.00	30 35	35 00
......	.....	1.62	1.62	1.64	2.24	5.20	2.56	10.00	....	7.44	7.00	3.32	3.00	16 55	27 00
0.78	1.08	1.06	2.92	1.64	8.12	1.62	0.96	10.70	9.00	9.74	8.00	6.45	4.00	24 98	25 00
0.62	0.58	1.06	2.26	2.05	5.20	2.13	1.49	8.82	8.00	7.33	7.00	8.59	8.00	22 56	28 00
1.69	.....	2.67	4.36	4.10	6.08	2.19	1.41	9.68	7.00	8.27	5.50	3.46	1.75	26 57	30 00
0.98	0.60	1.91	3.49	4.10	1.24	3.73	2.17	7.14	7.00	4.97	5.50	2.58	1.75	20 05	30 00
0.78	1.01	1.50	3.29	3.28	6.12	1.60	0.94	8.66	8.00	7.72	7.00	12.06	10.00	29 27	29 00
1.35	1.02	1.28	3.65	2.87	6.92	1.46	0.52	8.90	8.00	8.38	7.00	11.49	9.00	30 42	31 00
1.10	0.66	1.53	3.29	3.28	4.92	1.09	1.81	8.64	8.00	6.83	7.00	7.25	7.00	24 74	32 00
0.69	0.51	1.28	2.48	1.03	5.46	2.11	1.62	9.20	8.00	7.57	7.00	9.48	10.00	24 40	30 00
0.50	.....	1.25	1.75	2.05	1.48	6.53	1.82	9.83	9.00	8.01	8.00	3.14	3.00	16 94	28 00
1.34	0.88	1.24	3.46	2.46	6.48	1.49	0.77	8.74	9.00	7.97	8.00	12.57	10.00	30 40	32 00
......	.....	0.58	0.58	0.41	1.00	4.84	1.90	7.74	9.00	5.84	8.00	2.37	2.00	10 19	21 00
......	....	1.52	1.52	0.41	6.96	5.09	1.27	13.32	9.00	12.05	8.50	4.20	2.00	20 55	21 00
......	.....	1.47	1.47	0.27	6.68	5.51	1.37	13.56	9.00	12.19	8.50	4.29	2.00	20 61	20 00
1.29	1.74	0.99	4.02	3.28	6.42	1.23	0.75	8.40	8.00	7.65	7.00	11.18	10.00	30 83	32 00
......	.....	2.56	2.56	1.64	6.24	2.11	2.83	11.18	10.00	8.35	8.00	9.90	10.00	25 54	29 00
0.46	.....	1.25	1.71	2.05	3.08	5.28	2.64	11.00	9.00	8.36	7.00	5.37	3.00	17 60	26 00
0.83	0.30	1.12	2.25	2.05	3.96	3.87	1.91	9.74	....	7.83	7.00	4.99	4.00	20 06	25 00
0.45	.....	0.79	1.24	1.03	0.12	7.35	5.31	12.78	....	7.47	7.00	3.51	2.00	16 28	22 00
0.30	.....	0.62	0.92	0.82	1.44	5.87	1.88	8.64	10.00	7.31	9.00	2.57	1.75	12 44	23 00
1.48	1.81	0.64	3.93	3.46	6.16	1.75	0.94	8.85	9.00	7.91	8.00	8.86	10.00	28 77	34 00
1.46	.....	0.96	2.42	2.46	5.48	2.66	1.37	9.51	9.00	8.14	8.00	9.66	10.00	24 60	32 00
1.39	1.74	0.65	3.78	2.87	4.90	2.70	1.10	8.70	9.00	7.60	8.00	8.04	10.00	27 34	34 00
0.85	0.59	0.89	2.33	1.64	5.28	2.35	1.41	9.04	....	7.63	7.00	9.78	10.00	24 00	28 00
......	.....	0.90	0.93	0.82	0.76	6.55	1.64	8.95	11.00	7.31	10.00	2.32	1.00	12 64	23 00
1.11	.....	0.84	1.95	0.66	1.40	6.58	2.93	10.36	7.50	7.93	6.50	3.81	2.00	18 00	25 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
F. W. Tunnell & Co.—(Cont.)		
Dissolved Junk, Bone and Potash	Ringoes	5726
The J. E. Tygert Co., Philadelphia, Pa.		
Bone Phosphate	Cedarville	5863
Early Truck Guano	Erma	5425
Ten Per Cent. Sweet Potato Guano	"	5428
Vineland Grain Co., Vineland, N. J.		
Potato Manure	Vineland	5388
Bone Phosphate	"	5389
A. J. Vreeland, Matawan, N. J.		
Quick and Lasting Fertilizer, Truckers' Guano	Matawan	5548
* " " " " " "	"	5858
Complete Manure for General Use	"	5549
Special Potato Manure	"	5550
George M. Wells, Moorestown, N. J.		
Ten Per Cent. Truck Guano	Collingswood	5068
Tomato and Truck Manure	Bridgeboro	5017
High-Grade Potato Manure	"	5016
Early Potato Manure	Collingswood	5066
Prosperity Potato Manure	West Palmyra	5010
General Use Fish Guano	" "	5011
J. Wenderoth & Sons, Camden, N. J.		
Potato Fertilizer	Camden	5185
Ten Per Cent. Fertilizer for General Use	"	5184
West Jersey Marl and Transportation Co., Woodbury, N. J.		
Our Special White Potato Manure	Collingswood	5070
Our All Crop Mixture	Fairton	5835
Our Special Sweet Potato Manure	"	5837
* " " " " "	Sewell	5236
Our High-Grade Truck Manure	Fairton	5836
Bone and Potash Compound	Sewell	5234
John Whann and Son, Philadelphia, Pa.		
† Raw Bone Phosphate	Camden	5805
† Special Mixture	Marlton	5368
† Imperial Potato Manure	Camden	5804
† Reliable Ammoniated Superphosphate	Marlton	* 5369
W. E. Whann, William Penn, Pa.		
Chester Valley Fish and Potash Fertilizer	Vineland	5885
" " Ten Per Cent. Potato Manure	Blackwood	5211
" " Special Potato and Truck Fertilizer	Cedarville	5866
" " Available Ammoniated Phosphate	Blackwood	5210

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumer's Depot.
......	.....	0.36	0.36	0.27	1.00	7.49	2.00	10.49	7.00	8.49	6.00	1.89	2.00	$11 38	$16 25
......	......	1.66	1.66	1.85	6.38	2.40	1.92	10.70	11.00	8.78	9.00	2.76	2.50	17 16	25 00
0.63	......	2.05	2.68	3.28	4.42	2.82	2.70	9.94	7.00	7.24	6.00	2.40	2.00	19 37	28 00
0.58	......	1.27	1.85	1.23	3.72	3.08	1.43	8.18	8.00	6.75	7.00	7.49	10.00	19 68	28 00
0.51	......	0.86	1.37	1.64	3.88	3.74	1.18	8.80	....	7.62	7.00	9.99	10.00	20 73	30 00
......	0.20	0.85	1.05	1.03	6.58	1.50	0.80	8.88	9.50	8.08	8.50	1.96	1.50	13 10	25 00
0.46	1.84	1.49	3.79	4.92	6.78	1.64	1.48	9.90	8.00	8.42	7.00	6.12	6.00	26 88	33 00
0.24	3.55	0.94	4.73	4.92	5 92	1.85	1.11	8.88	8.00	7.77	7.00	*5.92	6.00	29 65	33 00
......	0.74	1.51	2.25	2.46	6.48	2.60	2.65	11.73	11.00	9.08	9.00	4.14	4.00	20 93	26 50
1.80	1.12	0.48	3.40	3.28	4.80	3.62	1.84	10.26	....	8.42	8.00	9.12	8.00	27 89	32 00
2.18	2.85	2.66	7.69	8.20	5.00	0.98	0.64	6.62	....	5.98	4.00	5.20	4.00	37 29	44 00
1.48	1.23	2.58	5.29	4.92	7.00	1.38	1.42	9.80	....	8.38	7.00	4.67	4.00	30 88	34 00
0.86	0.84	1.19	2.89	2.87	6.68	1.58	0.98	9.24	....	8.26	7.00	9.43	9.00	26 10	30 00
0.71	1 04	1.68	3.43	3.49	5.08	2.06	1.16	8.30	....	7.14	5.00	7.98	7.00	25 94	30 00
0.58	......	1.08	1.66	1.86	5.46	2.16	1.26	8 88	....	7.62	7.00	10.36	10.00	22 14	28 00
0.65	......	1.14	1.79	2.05	5.74	1.72	1.64	9.10	....	7.46	6.00	4.99	4.00	18 04	23 00
0.63	0.68	1.91	3.22	3.28	7.00	1.83	1.04	9.87	7.00	8.83	5.00	7.49	7.00	26 33	32 00
2.01	2.22	3.82	8.05	8.20	4.02	1.42	1.65	6.09	....	5.44	5.00	6.00	4.00	39 00	44 00
0.94	......	1.84	2.28	2.46	6.08	1.19	0.70	7.97	....	7.27	6.00	8.48	8.00	22 19	28 00
......	0.66	1.44	2.10	2.05	6.48	1.07	0.93	8.48	....	7.55	6.00	4.34	4.00	18 49	23 00
......	0.74	0.67	1.41	1.64	6.86	1.56	0.77	9.19	....	8.42	8.00	9.35	10.00	20 91	28 00
0.79	......	0.91	1.70	1.64	6.36	2.05	1.66	10.07	....	8.41	8.00	9.59	10.00	22 44	28 00
1.83	......	1.37	3.20	3.28	5.96	2.57	1.09	9.62	....	8.53	8.00	7.06	7.00	25 40	33 00
0.89	......	1.05	1.94	1.64	2.86	6.34	4.74	12.94	....	8.20	8.00	2.97	3.00	18 73	25 00
0.39	......	1.16	1.55	1.85	6.62	2.18	1.84	10.64	11.00	8.80	9.00	2.64	2.50	16 52	25 00
0.31	......	1.13	1.44	1.44	5.16	2.21	1.49	8.86	....	7.37	7.00	6.84	6.00	17 85	25 00
0.87	......	1.35	2.22	2.46	4.74	1.99	1.61	8.34	....	6.73	7.00	6.61	6.00	20 28	27 50
0.67	......	1.00	1.67	1.64	5.60	2.46	1.54	9.60	10.00	8.06	8.00	2.14	2.00	15 57	23 00
0.61	......	0.94	1.55	1.48	5.10	2.05	1.04	8.19	....	7.15	8.00	6.60	6.00	17 16	28 00
1.01	......	1.94	2.95	3.28	3.88	2.08	1.56	7.52	7.00	5.96	6.00	10.05	10.00	25 12	33 00
0.68	0.29	1.57	2.54	2.48	4.46	1.98	1.61	8.05	8.50	6.44	7.00	6.84	7.00	20 65	30 00

2. Ground Bone.

Twenty-eight samples of ground bone were examined this year, and with one exception were accompanied by guarantees, as required by law. Twenty-one of the samples satisfied their guarantees, but six were low in nitrogen and one in phosphoric acid. In composition, the samples ranged from 1.08 to 5.29 per cent. of nitrogen, with an average of 2.99 per cent., and from 10.54 to 29.68 per cent. of phosphoric acid, with an average of 23.81 per cent. There were wide variations in the mechanical condition of the samples. In the finest sample, 91 per cent. would pass through a one-fiftieth-inch sieve, and in the coarsest only 38 per cent.

The average fineness and composition of the samples this year, *together with the average valuation and selling price*, as compared with the last five years, are shown as follows:

	Fine. Per cent.	Coarse. Per cent.	Nitrogen. Per cent.	Phosphoric Acid. Per cent.	Valuation.	Selling Price.
Average for 1900	63	37	3.24	23.33	$25 88	$28 70
" " 1901	52	48	3.20	24.20	26 09	28 98
" " 1902	57	43	3.05	25.41	26 85	26 97
" " 1903	59	41	3.00	24.41	26 37	28 04
" " 1904	57	43	3.25	23.95	26 91	28 46
" " 1905	65	35	2.99	23.81	27 07	27 95

The average valuation was $27.07 and the selling price $27.95, a difference of $0.88, or 3.3 per cent.

3. Miscellaneous Fertilizers and Sundry Materials.

Of the twenty-three samples of miscellaneous fertilizers, all but one were accompanied by guarantees. The available phosphoric acid was deficient in six cases and the potash in four. Fifteen are plain superphosphates, with potash. In ten of these mixtures the brand name indicates that bone enters into their composition, but the analysis shows that the phosphoric acid is derived from mineral sources only. These furnished plant-food at an average valuation of $12.91, with an average price of $18.13, an advance of $5.22, or 40.4 per cent.; this is even higher than in the case of complete fertilizers. By giving to the potash the regular Station's valuation of 4.25 cents per pound, it is found that the available phosphoric acid

in these materials, on the average, cost 7.5 cents per pound, showing what an excessive price the consumer paid for acid phosphate under the guise of bone.

The samples of dry and liquid "Bonora" are new preparations recommended as "good for all flowering plants, vegetables, strawberries, lawns, trees, etc., producing a lasting and healthy growth." These are both concentrated fertilizers intended to be used in small quantities. Both of these samples came to the Station from the manufacturer in the original packages—the dry sample in a tin box, containing 307 grams of the material, and the liquid in a bottle, the solution measuring 395 cubic centimeters and weighing 491 grams. The ingredients were soluble in water. The percentages of the plant-food elements found are reported in the regular tables, while the following tabulation shows the weight in grams of the different ingredients found in the amounts of materials sold in the respective containers:

	Dry. gms.	Liquid. gms.
Nitrogen, as nitrates	14.98	9.28
" " ammonia salts	31.68	18.46
" total	46.66	27.74
Available phosphoric acid	14.80	10.90
Potash	14.37	8.88

Sample No. 5799 was sold as a regular tankage, although its guarantee and its actual composition would indicate that it is properly a garbage tankage, which it strongly resembles in appearance. The selling price, $24 per ton, is very high for material of this character.

Ground Bone

Furnishing Nitrogen and Phosphoric Acid.

Station Number.	BRAND.	MANUFACTURER.
5191	Ground Bone	American Agricultural Chemical Co., N. Y. City
5741	Fine Ground Bone	" " " " " "
5048	Ground Bone	" " " " " "
5666	Fine Ground Bone	" " " " " "
5742	Pure Ground Bone	" " " " " "
5801	Bone Meal	Armour Fertilizer Works, Baltimore, Md.
5241	Raw Bone Meal	" " " " "
5258	Raw Bone Meal	Baugh & Sons' Co., Philadelphia, Pa.
5744	Raw Bone Fine	The Berg Co., Philadelphia, Pa
5605	XXX Pure Ground Bone	E. Frank Coe Co, New York City
5135	Pure Ground Bone	J. S. Collins & Son, Moorestown, N. J.
5611	Pure Ground Bone	Hendrickson & Dilatush, Robbinsville, N. J.
5705	Pure Ground Bone	Ira Hill, Copper Hill, N. J.
5506	"I" Increase Crescent Bone Dust	Lister's Agricultural Chemical Works, Newark, N. J.
5786	Bone Meal	" " " " " "
5807	Pure Ground Bone	The Mapes Formula and Peruvian Guano Co., New York City
5828	Button Bone	L. Moritz, Philadelphia, Pa.
5794	Raw Bone Meal	Muzzy Bros., Paterson, N. J.
5326	Bone Meal	Nassau Fertilizer Co., New York City
5150	Swift Sure Bone Meal	M. L. Shoemaker & Co., Philadelphia, Pa.
5772	Bone Meal	G. F. Taylor, New York City
5171	Button Bone Dust	Taylor Bros., Camden, N. J.
5172	Pure Raw Bone Meal	" " " "
5029	Ground Bone	I. P. Thomas & Son Co., Philadelphia, Pa.
5844	Raw Bone	" " " " " " "
5686	Pure Ground Bone	Trenton Bone Fertilizer Co., Trenton, N. J.
5827	Button Bone Dust	Emil Wahl Mfg. Co., Philadelphia, Pa
5455	Pure Bone Sawings	Winterbottom, Carter & Co., Egg Harbor, N. J.

Ground Bone

Furnishing Nitrogen and Phosphoric Acid.

WHERE SAMPLED.	Station Number.	Mechanical Analysis.		Chemical Analysis.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
		Finer than 1-50th in.	Coarser than 1-50th in.	Nitrogen.	Phosphoric Acid.		
Woodbine	5191	77	23	2.58	24.48	$27 15	$22 75
Martinville	5741	67	33	2.67	25.66	27 58	26 00
Moorestown	5048	67	33	1.08	29.68	25 35	20 00
Baptisttown	5666	67	33	1.82	18.10	19 23	24 00
Roselle	5742	61	39	4.34	19.94	28 33	30 50
Morristown	5801	65	35	2.87	25.98	28 29	29 00
Salem	5241	77	23	3.57	25.06	30 93	30 00
Pitman	5258	56	44	3.56	22.40	27 19	30 00
Plainfield	5744	45	55	3.72	21.00	26 83	33 00
Hightstown	5605	55	45	2.21	29.28	27 75	28 00
Moorestown	5185	73	27	1.80	23.66	23 64	28 00
Robbinsville	5611	80	20	2.64	25.50	28 36	28 00
Copper Hill	5705	51	49	3.78	21.34	26 74	27 00
Matawan	5506	66	34	2.86	10.54	15 42	25 00
Passaic	5786	38	62	3.55	25.16	27 59	33 00
Morristown	5807	38	62	3.92	22.32	26 76	32 50
Bridgeton	5828	86	14	2.94	26.00	30 24	31 00
Paterson	5794	59	41	3.66	22.22	27 64	......
Bridgeton	5826	79	21	1.61	19.90	20 54	28 00
Moorestown	5150	64	36	5.29	24.80	35 20	28 80
Freehold	5772	67	33	1.12	29.28	25 16	23 00
Camden	5171	91	9	2.85	24.80	29 40	29 00
"	5172	60	40	3.52	22.76	27 66	30 00
Hightstown	5029	57	43	2.83	25.96	27 50	28 00
Windsor	5844	43	57	3.66	24.54	27 98	28 00
Lambertville	5686	67	33	2.88	24.78	27 61	27 00
Bridgeton	5827	74	26	3.12	25.00	29 13	30 00
Egg Harbor	5455	90	10	3.72	26.60	33 77	27 00

Miscellaneous Fertilizers

Furnishing Nitrogen, Phosphoric Acid or Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
American Agricultural Chemical Co., N. Y. City.		
Peach Tree Special	Hightstown	5599
Great Eastern Soluble Bone and Potash	Morristown	5749
Packers' Union Banner Wheat Grower	Baptisttown	5681
Quinnipiac Dissolved Bone and Potash	Everittstown	5683
Read's 10 and 8	Blairstown	5823
Sharpless and Carpenter's Soluble Bone and Potash	Bloomsburg	5720
Tygert-Allen's Star Soluble Bone and Potash	Jackson's Mills	5483
Williams & Clark's Dissolved Bone and Potash	East Millstone	5766
Baugh & Sons' Co., Philadelphia, Pa.		
Pure Dissolved Animal Bone	Elberon	5461
Bonora Chemical Co., Kearny, N. J.		
Bonora, liquid	Manufacturer's Sample	5851
" dry	" "	5852
Bowker Fertilizer Co., Boston, Mass.		
Superphosphate with Potash	Washington	5818
E. Frank Coe Co., New York City.		
High-Grade Dissolved Bone and Potash	Hopewell	5653
A. A. Cortelyou, Neshanic, N. J.		
Special for All Crops	Neshanic	5703
Eagle Guano Co., New York City.		
*Tankage	Paterson	5799
Lister's Agricultural Chemical Works, Newark, N. J.		
Animal Bone and Potash	Lebanon	5730
Alkaline Bone	Middlebush	5760
I. P. Thomas & Son Co., Philadelphia, Pa.		
Special Alkaline Bone	White House	5736
Alkaline Bone	" "	5737
Trenton Bone Fertilizer Co., Trenton, N. J.		
Top Dressing for Grass	Sewell	5231
F. W. Tunnell & Co., Philadelphia, Pa.		
Raw and Acidulated Bone	White House	5740
*Dissolved Tankage	Ringoes	5839
*Crude Fish and Dissolved Hair	Delanco	5840

* Not an official sample.

Miscellaneous Fertilizers

Furnishing Nitrogen, Phosphoric Acid or Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
....	....	....	....	....	8.20	2.56	2.42	13.18	11.00	10.76	10.00	7.14	8.00	$16 72	$19 00
....	....	....	....	....	8.12	2.41	2.81	12.84	12.00	10.53	11.00	2.94	3.00	12 90	18 00
....	....	....	....	....	8.60	3.00	2.76	14.36	11.00	11.60	10.00	2.05	2.00	13 28	16 00
....	....	....	....	....	7.76	3.20	3.74	14.70	11.00	10.96	10.00	2.13	2.00	13 17	16 00
....	....	....	....	....	8.90	1.91	1.19	12.00	11.00	10.81	10.00	7.06	8.00	16 21	22 00
....	....	....	....	....	6.58	3.28	2.26	12.12	11.00	9.86	10.00	1.90	2.00	11 39	17 00
....	....	....	....	....	6.84	2.75	1.16	10.75	11.00	9.59	10.00	2.85	2.00	11 52	16 00
....	....	....	....	....	6.72	3.11	2.28	12.11	11.00	9.83	10.00	1.86	2.00	11 34	18 00
....	0.72	1.60	2.32	2.05	0.96	13.05	1.97	15.98	....	14.01	13.00	....	....	21 84	35 00
1.89	3.76	....	5.65	....	2.22	....	....	2.22	....	2.22	....	1.81	....	....	....
4.38	10.82	....	15.20	15.93	4.82	....	....	4.82	5.49	4.82	5.49	4.68	3.13	....	....
....	....	....	....	....	9.44	2.63	1.17	13.24	11.00	12.07	10.00	0.83	1.00	12 05	20 00
....	....	....	....	....	6.64	2.73	5.01	14.38	12.50	9.37	10.50	2.02	2.00	12 16	20 00
....	....	....	....	....	6.04	2.53	3.38	11.90	9.00	8.57	8.00	4.87	5.00	13 18	17 00
....	....	2.26	2.26	2.46	0.00	1.34	0.88	2.22	....	1.34	....	0.92	1.00	....	24 00
....	....	....	....	....	6.64	2.11	1.15	9.90	10.00	8.75	9.00	5.70	5.00	15 19	20 00
....	....	....	....	....	7.96	2.53	1.57	12.06	....	10.49	10.00	1.50	2.00	11 55	17 00
....	....	....	....	....	3.76	6.43	1.53	11.72	11.00	10.19	10.00	*5.05	4.00	14 48	19 00
....	....	....	....	....	6.54	3.38	0.96	10.88	12.00	9.92	10.00	1.67	2.00	10 73	17 00
10.19	....	1.69	11.88	11.48	0.26	2.55	0.77	3.58	....	2.81	4.00	....	....	43 74	53 00
....	....	2.39	2.39	1.64	7.24	4.03	6.21	17.48	20.00	11.27	10.00	....	....	21 47	26 00
....	....	6.96	6.96	4.10	2.72	2.32	1.98	7.02	10.00	5.04	....	....	....	....	25 00
0.28	1.55	5.65	7.48	5.69	1.20	5.86	1.26	8.32	10.00	7.06	....	....	....	....	25 00

*Potash largely, if not entirely, from sulphate.

Sundry Materials.

5012. Muck. Sent by Mr. Campbell, Cedarville.

5013. New York City Stable Manure. Old. Sent by C. C. Hulsart, Matawan.

5014. New York City Stable Manure. New. Sent by C. C. Hulsart, Matawan.

5045. Wool Waste. Made by Jos. Gubbins. Sent by E. S. Dobbs, Gloucester. Selling price, $3 per ton.

5834. Humus Fertilizer. Sent by D. T. Millspaugh, Paterson. Guaranteed to contain 3 per cent. ammonia.

5859. Bog Ashes. Sent by J. J. Mitchell, Whippany. Selling price, $6 per ton.

	5012	5013	5014	5045	5834	5859
Nitrogen	0.25	0.62	0.91	2.65	1.35	....
Phosphoric Acid	0.43	0.53	0.61	0.40	....	2.21
Potash	0.29	0.39	0.75	2.79	....	0.41
Lime	....	....	....	....	....	7.23
Water	14.70	75.88	60.58	....	....	....
Organic Matter	7.98	16.36	32.33	....	....	....
Ash	77.32	7.76	7.09	....	....	....

FODDERS AND FEEDS.

I.

CONCENTRATED FEEDING STUFFS.

Inspection.

On the following pages is presented the work of the Station in its fifth examination of the concentrated feeding stuffs sold in the State, under the law of March 15th, 1900.

Four hundred and forty-nine samples were collected, of which 353 required guarantees and ninety-six did not. Of these, 397 were selected for analysis; 302 belonged to the class that required guarantee, while ninety-five belonged to the non-guarantee class.

Guarantees and Actual Composition.

Of the 353 samples received which required a guarantee, 118 were not so accompanied. In the case of all but fifteen of these, however, the guarantees were supplied to the Station by correspondence with the manufacturer or dealer. The filing of this information with the Station is, however, not a satisfactory substitute for a guarantee which is missing in the sale of the goods. In the great majority of cases the manufacturers are not at fault, for with very few exceptions they are willing to aid in the enforcement of the Feed law. It is probably true that but few lots of feed are shipped from the factory without either a tagged or branded bag, or the guarantee attached to the car containing the shipment. Either method of guarantee is in harmony with the requirements of the law. It would seem, therefore, that the absence of a guarantee is frequently due to carelessness on the part of the dealer. It is also true that this carelessness is generally encouraged by the consumer's failure to demand a guarantee.

The samples received represent 159 different brands, fourteen of which were devoid of all information as to their composition. This is 9 per cent. of the total number, and, while slightly greater than the number deficient last year, yet, compared with 12 per cent. in 1903,

13 per cent. in 1902, and 32 per cent. in 1901, shows an increasing compliance with the requirements of the law on the part of the manufacturers.

Three hundred and two samples requiring a guarantee were analysed this year. The guarantees, when given, were fulfilled in 174 samples —that is, 60 per cent. of the samples fulfilled their promises, a proportion somewhat higher than last year, but considerably lower than in either 1903 or 1902. Of the 114 deficient samples, seventy-five were low in protein, twenty in fat and nineteen in both protein and fat. The following tabulation shows the classes of feeds in which one or more samples failed to reach the guarantee in protein or fat; forty-one, or 36 per cent., of these deficiencies occur in the feeds derived from corn, notably gluten feed, hominy, corn bran and maizeline.

Of the twenty-seven gluten feeds which were guaranteed, eighteen were low in protein. The poor quality of the corn crop has been used repeatedly as an excuse for the failure of these feeds to reach their guarantees, but the manufacturers should now recognize the fact that the corn is of poor quality and lower their guarantees accordingly. Under present conditions of crop and methods of manufacture, it would seem that not over 25 per cent. of protein should be guaranteed in gluten feeds.

Linseed meal shows a great improvement over last year, the average sample containing 2.28 per cent. more protein. A number of deficiencies occur in the distillery and brewery products, partly because in certain cases the guarantees are rather high for materials of this class, but even more because of the difficulty of maintaining the uniformity of the product. That these increased deficiencies do not arise from inferiority of the feeds in question is shown by the fact that their average protein content is practically the same as last year, although nineteen samples are low in protein as compared with six last year. The proprietary mixed feeds compare very favorably with those of previous years, although quite a large proportion show a marked deficiency in protein.

FEEDS NOT REACHING GUARANTEES.

	Total Number of Samples.	Below in Protein.	Below in Fat.	Below in Protein and Fat.		Total Number of Samples.	Below in Protein.	Below in Fat.	Below in Protein and Fat.
ottonseed Meal	14	3	1	......	Schumacher's Stock Feed	8	1	......	......
inseed Meal	40	6	1	......	Vim Oat Feed	2	1	......	......
erm Oil Meal	1	......	......	1	Biles' Ready Ration	2	1	......	......
hicago Gluten Meal	1	1	......	......	Blomo Feed	8	1	......	......
lint Gluten Feed	4	4	......	......	Buffalo Creamery Feed	2	1	......	......
uffalo Gluten Feed	8	7	......	......	Holstein Sugar Feed	8	2	......	......
adger Gluten Feed	1	1	......	......	Friends' Oat Feed	2	1	......	1
lobe Gluten Feed	9	2	......	......	Royal Oat Feed	4	2	......	1
Varner's Gluten Feed	4	4	......	......	H. O. Horse Feed	8	......	1	......
undry Gluten Feeds	5	2	......	......	Nutro Glen	1	1	......	......
ominy Meal	24	2	7	5	Crackerjack Dairy Feed	1	1	......	......
orn Bran	8	2	......	......	Cornelia Dairy Feed	1	......	......	1
aizeline Feed	5	2	......	1	Blue Grass Mixed Feed	1	1	......	......
iles' Fourex Grains	2	2	......	......	Barley Feed	8	1	1	......
jax Flakes	3	2	......	......	Peanut Bran	1	1	......	......
ontinental Gluten Feed	1	1	......	......	Peanut Middlings	1	......	......	1
agle Corn Distillers' Grains	1	......	......	1	Rice Feed	1	......	......	1
alt Sprouts	25	6	1	......	H. O. Poultry Feed	2	1	......	......
ried Brewers' Grains	86	5	1	2	H. and L. Poultry Food	1	......	1	......
olasses Grains	4	2	......	......	Blatchford's Calf Meal	1	1	......	......
uaker Dairy Feed	8	8	......	......	Local Mixtures	19	1	6	4
					Totals	256	75	20	19

Adulterations.

Nine samples of the feeds examined were unquestionably adulerated. The seven samples of linseed meal of A. L. Clements & Co. ontained ground cocoa shells in varying quantities, the analysis inlicating that on the average about one-fifth of these samples con-

sisted of that material. Although only two of the seven samples fell materially below the protein guarantee, their average protein content was but 30.32 per cent., as compared with 34.27 per cent. in the unadulterated samples, the average selling prices being $31.33 and $32.44, respectively. One sample of dried brewers' grains (No. 5377) contained coffee hulls, and the sample of Kidder's mixed feed, apparently sold as straight wheat feed and unguaranteed, contained much corncob.

Inferior Feeds.

Quite a number of the feeds examined contained foreign material. This material may have been added for purposes of adulteration, or may have been introduced accidentally during the manufacture or shipping of the feed. As in none of these cases is there any convincing evidence of adulteration, these feeds have simply been classed as inferior feeds. One sample of the Milwaukee linseed meal (No. 5065) contained considerable of a corn produuct, resembling corn oil cake in appearance; the sample contained over 2 per cent. less protein than guaranteed. One sample of Hunter's cottonseed meal (No. 5195) contained an excess of hulls, sufficient to reduce its protein nearly 5 per cent. below the average. The sample of Douglas gluten feed (No. 5235), and one sample of Globe gluten feed (No. 5209), contained an excess of corn bran, the samples being 5 per cent. below their protein guarantee. The samples of Flint or Warren gluten feed (Nos. 5058 and 5392), particularly the former, were of inferior quality and from 5 to 9 per cent. below their protein guarantee. The manufacturer having raised a question as to the sampling of these feeds, new samples were drawn from the stock of the same dealers and analysed; the analyses of the new samples were strictly in accord with those of the official samples. Fourteen of the twenty-four samples of hominy meal showed a high fiber content, ranging from 4.05 to 8.75 per cent.; one of these (No. 5004) contained oat hulls; two others (Nos. 5346 and 5352) contained considerable corn meal; the other eleven samples, especially Nos. 5030, 5057, 5532, 5070, 5018 and 5157, contained corncob in varying quantities. One sample of maizeline (No. 5303) contained an excess of corn bran. Four samples of dried brewers' grains (Nos. 5345, 5201, 5314 and 5068) contained light oats or oat hulls in considerable quantities. Three of the samples of barley feed contained light oats and oat hulls, and

No. 5166 contained rather an excess of barley hulls. Both samples of rice feed contained excessive rice hulls, the crude fiber averaging over 23 per cent. The spring wheat brans, with two exceptions, were of unusually poor quality as regards protein, but no adulteration was observed in any case. The samples of feeding flour, likewise, were considerably below standard quality. Three samples sold as "mixed feed" were of very inferior quality, and a doubt is raised as to the straightforwardness of their sale. Two of them ("Jersey Mixed Feed" and "Blue Grass Mixed Feed") were guaranteed; the other ("Kidder's Mixed Feed") was not guaranteed, and apparently was intended to represent genuine wheat feed. All of these samples contained ground corncobs, thereby decreasing the protein about 5 per cent., and nearly doubling the crude fiber. The tags supplied by the manufacturer of "Jersey Mixed Feed" clearly stated that corncob had entered into its composition; its selling price was about $6 below that of pure wheat feed. Two different tags were received from the manufacturer of "Blue Grass Mixed Feed"—one simply bearing the guarantee, the other stating, in addition, that corncobs had been used in the mixture. The doubt therefore arises as to whether in all cases the presence of corncobs in this feed was clearly made known to the intending purchaser, as the selling price was only slightly lower than that of the pure feed. Three samples sold as rye feed were nothing more than ground rye, and were over 4 per cent. lower in protein than genuine rye feed. One corn meal (No. 5267) contained nearly 25 per cent. of moisture, thereby greatly reducing the protein and fat content. One sample sold as buckwheat bran (No. 5182) contained but 9.69 per cent. protein and 26.88 per cent. fiber; it consisted very largely of buckwheat hulls; its selling price, however—$10 per ton—was less than half that asked for bran of good quality. Attention is again called to the fact that the buckwheat products are extremely variable, and that the name under which they are sold has little significance. This year, samples sold as middlings ranged from 19.36 to 31.19 per cent. protein; those sold as bran from 9.69 to 32.69 per cent., and those sold as feed from 17.75 to 27.38 per cent.

FEEDS NEW TO THE STATE.

FEED.	Water.	Crude Fat.	Crude Fiber.	Protein.	Ash.	Nitrogen-free Extract.	Nitrogen.	Phosphoric Acid.	Potash.
Cocoanut Cake	4.17	21.96	8.32	20.44	5.95	39.16	3.27	1.28	2.53
Cocoanut Meal	9.88	16.97	7.40	20.63	6.60	38.52	3.30	1.85	2.35
Warren Gluten Feed	7.52	2.83	7.29	18.25	0.86	63.25	2.92	0.37	0.12
Flint Gluten Feed	6.71	3.29	6.50	22.32	1.20	59.98	3.57	0.44	0.10
Badger Gluten Feed	7.45	6.01	7.06	24.32	1.06	54.10	3.89	0.29	0.05
Piel Bros.' Gluten Feed	4.83	2.81	6.11	27 93	0.85	57.47	4.47	0.35	0.07
Douglas Gluten Feed	7.34	4.77	7.70	20.94	1.09	58.16	3.35	0.48	0.07
Germaline	8.72	2.60	4.84	12.32	4.90	66.62	1.97	2.16	1.36
Fourex Distillers' Grains	4.83	13.94	10.76	29.69	1.54	39.19	4.75	0.59	0.11
" " "	5.72	10.76	13.04	29.06	1.97	39.45	4.65	0.59	0.18
Manhattan Stock Food	5.87	17.27	10.34	34.12	1.35	31.05	5.46	0.62	0.10
Merchants' Feed	4.93	12.97	11.55	31.00	1.79	37.76	4.96	0.62	0.18
Continental Gluten Feed	5.83	11.56	11.52	29.69	1.90	39.45	4.75	0.58	0.19
Climax Distillers' Grains	5.08	11.54	10.60	34.59	2.52	35.67	5.54	1.09	0.36
"N" Distillers' Grains	4.71	10.15	12.28	24.06	2.23	46.62	3.85	0.65	0.22
Proteino Corn Distillers' Grains	2.78	10.08	9.75	33.75	1.94	41.70	5.40	0.72	0.14
Eagle Corn Distillers' Grains	5.71	9.31	15.48	20.63	1.88	47.09	3.30	0.45	0.09
Sucrene Dairy Feed	8.12	4.61	10.70	16.94	6.33	53.30	2.71	0.84	1.85
Sucrene Horse Feed	8.05	3.99	9.64	14.56	6.77	56.99	2.33	0.69	2.06
Biles' Ready Ration, Union Grains	6.96	7.44	9.22	21.94	7.50	46.94	3.51	1.46	0.81
Buffalo Corn and Oat Chop	6.50	4.76	9.67	9.50	3.80	65.77	1.52	0.90	0.64
Holstein Sugar Feed	7.76	3.66	7.53	15.43	6.99	58.63	2.47	1.05	1.39
Protena Dairy Feed	6.38	4.70	19.42	19.00	7.52	42.98	3.04	1.14	1.66
Peanut Bran	6.86	1.68	65.05	5.50	3.64	17.87	0.88	0.15	0.69
Peanut Middlings	6.44	2.71	47.86	8.07	[2]11.53	23.39	1.29	0.28	0.96
Rice Feed	6.54	4.57	22.79	6.50	[1]16.53	43.07	1.04	1.23	0.66
" "	8.03	4.10	23.62	7.25	[3]15.76	41.24	1.16	1.17	0.59
Buffalo Poultry Feed	7.69	5.00	5.87	17.13	3.13	61.18	2.74	1.44	0.81
Jersey Mixed Feed	6.92	3.50	15.09	11.82	5.39	57.28	1.89	2.22	1.41
Kidder's Mixed Feed	6.95	3.94	13.68	10.31	3.90	61.27	1.65	1.62	1.06
Blue Grass Mixed Feed	5.73	2.79	16.64	10.57	4.05	60.22	1.69	1.69	1.06

[1] Contains 12.95 per cent insoluble in hydrochloric acid.
[2] " 7.87 " " " " "
[3] " 13.03 " " " " "

The above table gives the analysis of a number of feeds which were either new to the State this year or were completely analysed by this Station this year for the first time. Among these are several feeds which promise to be of great value to cattle feeders; on the other

hand, there are a few that should be scrupulously avoided. Cocoanut cake is a comparatively new feed in this country, and is characterized by its high content of fat. Five new gluten feeds were found this year—Warren or Flint (these being names for the same product), Badger, Douglas and Piel Bros. The Piel Bros. feed is of high quality, and the Badger is also a high-class feed, the content of fat being nearly double that usually found in feeds of this nature. The Douglas, Flint and Warren feeds were hardly up to standard, the latter showing a marked deficiency in protein. "Germaline" is a corn product resembling corn bran, but containing only about half as much fiber as that feed. Eight new brands of dried distillers' grains were examined. Of these, the "Climax," "Proteino" and "Manhattan Stock Food" are of very high quality, containing on the average over 34 per cent. protein and from 10 to 17 per cent. fat. The other distillers' grains are also of high quality, although the "Eagle" grains are not up to the average expected for good grains. The table clearly indicates the great variability of these feeds and the importance of buying them only on guarantee. "Sucrene Dairy Feed" is a so-called "balanced" feed, consisting of corn, barley, oats, wheat bran, distillers' grains, cottonseed meal, malt sprouts, weed seeds and molasses; it is a little superior to wheat bran in composition and sells for about the same price. "Sucrene Horse Feed" is a somewhat similar material, consisting of corn, barley, oats, linseed meal, malt sprouts, weed seeds, salt and molasses. It is not as high grade as the "Sucrene Dairy Feed," and sells for a slightly higher price; however, compared with corn, or corn and oats, it contains 5 per cent. more protein and sells for practically the same price as those feeds. "Biles' Ready Ration (Union Grains)" is another of the "balanced" feeds, and is a mixture of distillers' grains, a corn product and malt sprouts, to which have been added small quantities of wheat feed, oats, cottonseed meal, linseed meal and salt. The particular sample examined was slightly below guarantee; a second sample, taken at the manufacturer's request from a different dealer, reached its guarantee in both particulars. It is somewhat similar in composition to gluten feed, although containing nearly double the amount of fat and being a somewhat more bulky feed; its selling price is about the same as gluten feed. "Buffalo Corn and Oat Chop" is a mixture of corn and oats, and does not differ materially, either in composition or price, from other mixtures of a similar nature. "Holstein Sugar Feed"

consists essentially of malt sprouts, corn, a wheat product and molasses; it occupies an intermediate place between the two Sucrene feeds and sells for about $2 less per ton. "Protena Dairy Feed" is another "balanced" feed, and consists chiefly of ground alfalfa hay, gluten feed, linseed meal, cottonseed meal and dried brewers' grains; it contains about 19 per cent. of protein and about the same amount of fiber. The samples of "Peanut Bran" and "Peanut Middlings" examined were both of very inferior quality, the fiber content being very high—65.05 and 47.86 per cent., respectively. These products would be much more appropriate as bedding material than as feeds. The samples of "Rice Feed," likewise, are of poor quality and contain an excessive amount of hulls. Great care is necessary in the purchase of the rice products, as they are extremely variable, both as to name and composition. Pure rice bran, consisting largely of the cuticle adhering to the grain, is a valuable feed, but unfortunately it is a very variable product—partly because of different methods of manufacture and partly because there is apparently little effort made to put the pure product on the market. A mixture of the pure bran and from 25 to 75 per cent. hulls is often sold as "rice bran;" likewise, a mixture of the bran, polish and hulls, which should properly be called "rice feed," is also sold as "rice bran;" and even the pure hulls, finely ground, are often similarly designated. Rice hulls possess but little feeding value, and the nature of their high content of fiber is such that when fed in large quantities they are positively dangerous. The tissues of the hull contain a large quantity of insoluble silica, which greatly retards digestion, and these silicified fibers are so harsh and sharp that when the hulls are eaten to any great extent a serious irritation of the delicate mucous membranes of the stomach takes place, attended by vomiting, and sometimes resulting in death. "Buffalo Poultry Feed" consists of a wheat product, corn and oats; it is not materially different from the other poultry feeds, either in composition or price. "Jersey Mixed Feed," "Kidder's Mixed Feed" and "Blue Grass Mixed Feed" have already been referred to under another heading. They are mixtures of wheat bran and ground cob. If sold as genuine wheat feed they are fraudulent in their nature; if sold for what they are the purchaser secures his corncob meal at an excessive price.

THE RELATIVE COST OF THE FEEDS.

Guaranteed Feeds.*

In order to consider the different guaranteed feeds on a more comparable basis the following table has been prepared, in which is shown the actual quantity of protein and fat which was secured in the different feeds for $1:

POUNDS OF PROTEIN AND FAT OBTAINED IN GUARANTEED FEEDS FOR ONE DOLLAR, AT CURRENT PRICES.

FEED.	Protein.	Fat.
Group 1. (29-43 Protein).		
Cottonseed Meal	29.5	6.5
Climax Distillers' Grains	25.1	9.4
Manhattan Feed	26.2	13.8
Linseed Meal	21.2	4.5
Chicago Gluten Meal	20.7	3.6
Merchants' Feed	23.8	10.0
Crackerjack Dairy Feed	25.5	11.6
Continental Gluten Feed	22.0	8.6
Biles' Fourex Grains	22.6	9.5
Ajax Flakes	21.5	9.7
Group 2. (20-26 Protein).		
Malt Sprouts	24.8	1.9
Globe Gluten Feed	20.4	2.6
Piel Bros'. Gluten Feed	21.5	2.2
Dried Brewers' Grains	22.8	6.5
Badger Gluten Feed	18.7	4.6
"N" Distillers' Grains	24.8	10.5
Buffalo Gluten Feed	19.0	2.2
Warner's Gluten Feed	18.7	3.7
Biles' Ready Ration	16.9	5.7
Douglas Gluten Feed	16.8	3.8
Eagle Distillers' Grains	16.5	7.4
Cornelia Dairy Feed	15.9	8.6
Cocoanut Cake	20.5	19.5
Germ Oil Meal	13.6	5.8
Flint Gluten Feed	16.2	2.4
Group 3. (17-20 Protein).		
Nutro Glen	15.7	3.6
Protena Dairy Feed	16.2	4.0
Buffalo Creamery Feed	13.8	3.5
Molasses Grains	18.1	4.0
H. O. Dairy Feed	12.6	3.5
Blomo Feed	13.8	1.1
Sucrene Dairy Feed	13.9	2.8
Group 4. (10-14 Protein).		
Holstein Sugar Feed	12.7	3.2
Sucrene Horse Feed	10.9	3.3
Barley Feed	11.0	3.0
Quaker Dairy Feed	10.7	3.3
H. O. Horse Feed	8.5	3.1
Schumacher's Stock Feed	9.3	3.3
Germaline	9.9	2.1
Buffalo Horse Feed	8.4	3.5
Jersey Mixed Feed	12.7	3.8
Corn Bran	10.8	2.7
Blue Grass Mixed Feed	11.0	2.9
Kidder's Mixed Feed	9.0	3.4
Imperial Dairy Feed	9.6	3.6
Group 5. (7-10 Protein).		
Hominy Meal	8.0	5.9
Buffalo Corn and Oats	8.0	3.9
Cerealine Feed	7.3	6.4
Maizeline Feed	7.1	6.2
De-Fi Corn and Oats	7.4	3.1
Excelsior Corn and Oats	7.3	5.5
Monarch Chop Feed	7.6	4.3
Victor Corn and Oats	7.6	4.1
Boss Corn and Oats	7.8	4.6
Dried Beet Pulp	7.3	0.5
Imperial Stock Food	6.9	0.4
Empire Feed	6.2	2.8
Group 6. (6-7 Protein).		
Rice Feed	7.1	4.5
Vim Oat Feed	7.6	3.9
Royal Oat Feed	7.6	3.0
Canada Oat Feed	6.9	3.1
Friends' Oat Feed	6.8	3.0

The feeds are arranged in six groups, based on their protein content. By this arrangement the question of digestibility may to a great extent be ignored, as the digestibility co-efficients of the various feeds composing the different groups, with few exceptions, vary within relatively narrow limits.

Omitting cocoanut cake, which because of its high fat content is practically in a class by itself, the average amounts of protein and fat, respectively, which may be obtained for $1 in the different groups are as follows: Group 1, 24.1 and 8.7 pounds; Group 2, 18.8 and 4.5 pounds; Group 3, 16.2 and 3.4 pounds; Group 4, 10.3 and 3.2 pounds; Group 5, 7.6 and 4.9 pounds, and Group 6, 7.2 and 3.5 pounds. As observed last year, it is noticeable that the amount of fat obtained in all the groups excepting the first is very uniform, varying from 3.2 to 4.9 pounds. It would appear, therefore, that with the exceptions noted the fat content has but little significance in the purchase of these feeds. On the other hand, from Group 1 to Group 6 there is a constant decrease of protein obtainable for the sum noted. Roughly speaking, the feeds of the first three groups may be considered protein feeds in distinction from those of the last three groups, which are essentially carbohydrate feeds. The nature of the feeder's business must decide him as to which class of feeds he will use—whether protein or carbohydrate feeds. If he is a purchaser of protein to supplement his home-grown feed, the table shows very clearly the folly of buying any of the feeds in the last three groups, for not only do many of these feeds contain no more protein than the materials he already possesses, but they also supply only from one-half to one-fourth as much protein as do the protein feeds of the first three groups. On the other hand, where carbohydrate feed is necessary, the purchase of certain of the feeds of the last three groups may be economical; the purchase of the feeds forming Group 6 cannot be recommended in any case. Having determined the amount of protein or carbohydrates which he wishes to buy, the feeder can readily decide by comparing the feeds of the different groups in which feed he can obtain the desired nutrients in the cheapest form.

Unguaranteed Feeds.

The following tabulation, calculated on the same basis as the one on an earlier page for the guaranteed feeds, shows the number of pounds of protein and fat that could be purchased in the various unguaranteed feeds for $1:

	Protein.	Fat.		Protein.	Fat.
Wheat Feed	12.7	3.9	Rye Bran	13.5	3.3
Wheat Middlings	11.6	3.4	Ground Rye	7.3	1.4
Wheat Bran, Winter	12.5	3.6	Buckwheat Middlings	27.9	7.9
Wheat Bran, Spring	12.0	4.4	Buckwheat Bran	19.4	5.3
Wheat Bran, Blended	12.9	3.8	Buckwheat Hulls	19.4	5.3
Wheat and Rye Middlings	9.9	2.1	Corn Meal	6.9	3.0
Feeding Flour	10.4	2.6	Corn and Oats	7.4	2.7
Rye Feed	11.3	2.5	Local Mixtures	7.2	3.2

The cheapness of the buckwheat products for the purchaser of protein is again apparent. Of the wheat products, the blended bran and wheat feed were the cheapest; rye bran was the cheapest of the rye products and slightly cheaper than wheat feed; all of the whole grain products were expensive sources of protein.

Average Composition and Selling Price.

The following table shows the average selling price of the several feeds, with their average composition, arranged in the order of their protein content:

	Protein. Per cent.	Fat. Per cent.	Fiber. Per cent.	Selling Price.
Cottonseed Meal	43.10	9.51	.....	$29.25
Climax Distillers' Grains	34.59	11.54	10.60	24.60
Manhattan Stock Food	34.12	17.27	10.34	26.10
Linseed Meal	34.27	7.32	.....	32.44
Proteino Corn Distillers' Grains	33.75	10.08	9.75	.....
Chicago Gluten Meal	32.13	5.51	.....	31.00
Merchants' Feed	31.00	12.97	11.55	26.10
Crackerjack Dairy Feed	30.62	13.95	7.15	24.00
Continental Gluten Feed	29.69	11.56	11.52	27.00
Biles' Fourex Grains	29.38	12.35	11.90	26.00
Buckwheat Middlings	29.31	8.34	4.95	21.12
Ajax Flakes	28.98	13.15	12.70	27.00
Piel Bros'. Gluten Feed	27.93	2.81	.....	26.00
Malt Sprouts	26.09	1.99	.....	21.08
Globe Gluten Feed	26.07	3.26	.....	25.68
Dried Brewers' Grains	25.71	7.33	.....	22.72
Badger Gluten Feed	24.32	6.01	7.06	26.00
Warner's Gluten Feed	24.18	4.54	.....	25.80
"N" Distillers' Grains	24.06	10.15	12.23	19.50
Buffalo Gluten Feed	23.85	2.68	.....	25.19
Biles' Ready Ration	23.85	7.31	.....	26.00
Douglas Gluten Feed	20.94	4.77	7.70	25.00
Buckwheat Bran	20.74	5.71	2.91	21.43
Eagle Distillers' Grains	20.63	9.31	15.43	25.00
Cornelia Dairy Feed	20.63	4.66	5.78	26.00
Cocoanut Cake	20.54	19.47	7.86	20.00
Germ Oil Meal	20.37	8.77	.....	30.00
Flint Gluten Feed	20.38	3.08	6.78	25.00
Nutro-Glen	19.57	4.52	7.60	25.00
Protena Dairy Feed	19.00	4.70	19.42	23.45
Buffalo Creamery Feed	18.94	4.73	10.31	27.50
Molasses Grains	18.80	4.18	10.58	20.88
H. O. Dairy Feed	18.53	5.13	9.85	29.50
Buckwheat Feed	18.47	4.44	15.10	.....
Blomo Feed	17.33	1.47	10.04	26.33
Sucrene Dairy Feed	16.70	4.50	11.55	24.00
Wheat Feed	15.48	4.77	7.79	24.59
Winter Wheat Bran	15.47	4.48	7.54	24.86
Blended Wheat Bran	15.47	4.54	8.11	24.00
Wheat Middlings	15.41	4.52	3.95	26.71
Feeding Flour	15.04	3.82	.....	29.13
Rye Bran	14.85	3.59	3.23	22.00
Rye Feed	14.13	3.09	3.30	25.00
Holstein Sugar Feed	14.06	3.54	8.76	22.30
Spring Wheat Bran	14.05	5.12	9.56	23.43
Sucrene Horse Feed	13.85	4.17	9.85	25.50
Barley Feed	13.50	3.64	9.49	24.63
Wheat and Rye Middlings	12.31	2.75	1.23	26.00

	Protein. Per cent.	Fat. Per cent.	Fiber. Per cent.	Selling Price.
Quaker Dairy Feed	12.62	3.89	17.08	23.67
H. O. Horse Feed	12.40	4.48	8.33	29.17
Schumaker's Stock Feed	12.33	5.00	8.36	26.60
Germaline	12.32	2.60	4.84	25.00
Buffalo Horse Feed	11.88	5.00	7.21	28.50
Jersey Mixed Feed	11.82	3.50	13.63	18.75
Corn Bran	11.34	3.00	11.74	22.13
Blue Grass Mixed Feed	10.57	2.79	16.64	19.25
Kidder's Mixed Feed	10.31	3.94	13.63	23.00
Imperial Dairy Feed	10.13	3.74	15.30	21.00
Hominy Meal	9.91	7.36	4.49	24.88
Ground Rye	9.71	1.93	1.29	26.67
Buckwheat Hulls	9.69	2.67	26.88	10.00
Corn and Oats (Provender)	9.44	3.46	3.76	25.48
Buffalo Corn and Oat Chop	9.41	4.61	10.48	23.50
Cerealine Feed	9.32	7.73	8.95	24.00
Maizeline Feed	9.25	8.08	8.08	26.00
De-Fi Corn and Oat Feed	9.25	3.84	12.39	25.00
Excelsior Corn and Oats Feed	9.12	6.92	10.08	25.00
Monarch Chop Feed	9.00	5.04	9.39	23.67
Corn Meal	8.71	3.85	.....	25.48
Victor Corn and Oat Feed	8.65	4.63	11.04	22.86
Boss Corn and Oats Feed	8.60	5.11	11.40	22.00
Peanut Middlings	8.07	2.71	47.86	.....
Dried Beet Pulp	8.06	0.58	16.00	22.00
Imperial Stock Food	7.93	0.48	17.70	23.00
Empire Feed	7.69	3.55	8.87	25.00
Rice Feed	6.88	4.34	23.21	19.38
Vim Oat Feed	6.50	3.31	22.69	17.00
Royal Oat Feed	6.10	2.42	24.28	16.08
Canada Oat Feed	5.88	2.64	24.29	17.00
Friends' Oat Feed	5.88	2.60	24.80	17.33
Peanut Bran	5.50	1.68	65.05	.....

Animal Meal and Poultry Feeds.

Bowker's Animal Meal	40.31	16.66	.....	45.00
Blatchford's Calf Meal	23.38	4.88	.....	60.00
H. & L. Poultry Feed	20.94	7.93	5.84	36.00
Buffalo Poultry Feed	17.13	5.00	5.87	34.00
H. O. Poultry Food	15.82	5.47	5.20	36.50
American Poultry Food	13.44	5.96	4.44	30.00

The Selection of Feeds.

An inspection of the above table confirms the oft-repeated statement that the price alone is no index of the feeding value of a feed. For instance, certain feeds, containing 34, 21, 15, 12 and 8 per cent. of protein, respectively, have the uniform selling price of $25 per ton. If protein, in particular, is the desired constituent, it is very apparent that the selection of the feed will determine the economy of the purchase. The list of feeds from which a selection may be made is composed of six quite well-defined groups. These range in protein from 43 to 5.50 per cent., and may be classed as follows:

1. Cottonseed meal, linseed meal, corn distillers' grains, gluten meal and high-grade buckwheat middlings, furnishing from 28.5 to 43 per cent. of protein, and costing from $21 to $32 per ton.

2. Malt sprouts, dried brewers' grains, whiskey distillery grains, gluten feeds, buckwheat bran, germ oil meal and high-grade feed mixtures, furnishing from 20 to 26 per cent. of protein, and costing from $19.50 to $30 per ton.

3. Wheat products, buckwheat feed, molasses grains, molasses feed mixtures and certain "balanced" feeds, furnishing from 15 to 19 per cent. of protein, and costing from $21 to $29.50 per ton.

4. Rye feed, barley feed, germaline, corn bran and certain of the better feed mixtures, furnishing from 10 to 14 per cent. of protein, and costing from $18.75 to $29 per ton.

5. Hominy meal, provender, maizeline, cerealine, corn meal, dried beet pulp, peanut middlings, buckwheat hulls and corn and oats feeds, furnishing from 7 to 10 per cent. of protein, and costing from $10 to $26 per ton.

6. *Rice feed, low-grade oat feeds and peanut bran, furnishing from* 5.50 to 7 per cent. of protein, and costing from $16 to $19 per ton.

Summary.

1. Of the 159 different brands of feed received, and which should have been guaranteed, fourteen failed to meet this requirement. Consumers should at all times insist upon a guarantee, except for milling products, for which no guarantee is required.

2. Of the 288 samples which were guaranteed, 114 were deficient, seventy-five of these being low in protein.

3. Of the ninety-five samples which did not require a guarantee, seventy-nine were of normal composition, twelve were of inferior grade and four were misbranded.

4. Nine samples were found to be adulterated—linseed meal with cocoa shells, dried brewers' grains with coffee hulls and wheat feed with corncob.

5. The constantly increasing number of brands upon the markets requires, on the part of the purchaser, close attention to the amount of nutrients guaranteed and the prices asked for the same.

6. The purchaser of protein will rarely find any feed containing less than 15 per cent. of protein a desirable or an economical purchase.

OIL CAKE MEALS.

COTTONSEED MEAL.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	American Cotton Oil Co., N. Y. City ("Prime").						
5171	C. A. Lippincott and Bro	Moorestown	44.63	43.00	8.63	9.00	....
5294	J. H. Ashton	Trenton	43.19	43.00	8.06	9.00	....
5295	L. B. Risdon Milling Co	"	41.43	43.00	9.56	9.00	....
5318	D. H. Rigg	Columbus	44.75	43.00	10.88	9.00	....
5358	A. G. Johnson	Bridgeton	45.50	43.00	8.96	9.00	....
5359	A. L. Colson and Son	Woodstown	40.63	41.00	8.85	9.00	....
5360	Peterson and Smith	"	43.75	41.00	11.84	9.00	....
	F. W. Brode and Co., Memphis, Tenn. ("Owl").						
5172	J. S. Collins and Son	Moorestown	44.06	43.00	10.04	9.00	....
5361	S. L Pancoast	Mullica Hill	41.88	43.00	10.53	9.00	....
5325	A. R. Ashby	Burlington	44.18	43.00	10.12	9.00	....
	Hunter Bros., St. Louis, Mo. ("Prime").						
5012	A. Cyphers	Newark	42.75	43.00	8.72	9.00	....
5195	Sharpless and Bro	Camden	38.69	43.00	9.67	9.00	12.83
	Hugh Pettit and Co., Memphis, Tenn. ("Horseshoe").						
5067	Mt. View Milling and Trading Co.	Mountain View	43.50	43.00	8.61	9.00	....
5104	Jaqui and Co	Morristown	44.50	43.00	9.19	9.00	....
	Average of all samples	....	43.10	42.71	9.51	9.00	....

LINSEED MEAL.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	American Linseed Co., N. Y. City.						
5005	Long Dock Mills and Elevator Co.	Jersey City	33.00	32.00	7.16	5.00	....
5025	J. H. Blauvelt and Son	Ridgewood	31.94	32.00	7.02	5.00	....
5026	Joseph English Co.	Paterson	34.32	32.00	7.46	5.00	....
5027	Meyer and De Vogel	"	35.13	32.00	7.14	5.00	....
5051	W. Stull and Bro	Madison	34.82	32.00	6.84	5.00	....
5170	C. A. Lippincott and Bro	Moorestown	34.94	32.00	7.40	5.00	....
5191	Sitley and Son	Camden	35.26	32.00	6.80	5.00	....
5264	Mundy Bros	Bound Brook	35.69	32.00	7.26	5.00	....
5296	L. B. Risdon Milling Co.	Trenton	37.00	32.00	7.12	5.00	....
5359	C. C. Dempsey	Gloucester	35.31	32.00	6.96	5.00	....
5355	Fithian and Pennell	Bridgeton	36.12	32.00	7.54	5.00	....
5356	A. G. Johnson	"	34.75	32.00	7.35	5.00	....
5384	The Hildebrant Co	Elizabeth	37.50	32.00	6.63	5.00	....
5017	Carscallen and Cassidy	Jersey City	35.44	32.00	7.64	5.00	....
5240	C. A. and T. P. Reed	Pennington	35.68	37.00	7.11	5.00	....
5363	J. K. Waddington	Salem	31.56	32.00	7.28	5.00	....
	Chapin and Co., Philadelphia, Pa. ("Export").						
5055	The Bailey and Winters Co.	Mountain View	34.81	36.00	8.00	7.00	....

OIL CAKE MEALS.

LINSEED MEAL—Continued.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN.		FAT.		Crude Fiber.
			Found.	Guaranteed.	Found.	Guaranteed.	
	A. L. Clements and Co., N. Y. City ("Cow").						
5006	J. C. Smith and Wallace Co	Newark	†29.06	30.00	7.72	5.50	9.98
5079	A. N. Roe and Son	Branchville	†31.43	30.00	8.15	5.50	....
5152	C. T. Mott and Co	Vernon	†31.56	32.00	7.41	5.50	....
5274	W. H. H. Wyckoff and Son	Raritan	†31.69	32.00	6.46	5.50	....
5286	C. W. Russell	New Brunswick	†29.82	32.00	7.44	5.50	8.43
5398	Jos. Benedict	Elizabeth	†28.94	30.00	7.66	5.50	9.31
6399	P. S. Dayton and Co	Plainfield	†29.75	30.00	7.19	5.50	8.72
	Flint Mill Co., Milwaukee, Wis. ("Green Oval").						
5083	Hart and Iliff	Newton	32.00	32.00	7.76	5.00	....
	Grove Linseed Oil Co., Philadelphia, Pa.						
5184	J. S. Collins and Son	Moorestown	35.19	32.00	7.85	5.00	....
5207	Taylor Bros	Camden	35.82	32.00	7.18	5.00	....
5208	E. Hollingshead	Moorestown	32.56	32.00	7.97	5.00	....
5357	S. L. Pancoast	Mullica Hill	36.19	32.00	7.20	5.00	....
5414	S. Anderson	Hammonton	34.88	32.00	6.59	5.00	6.02
	Hauenstein and Co., Buffalo N. Y.						
5224	G. G. McPherson	Lebanon	34.69	35.65	7.47	7.62	....
5393	Van Zant and Voorhees	Plainfield	35.37	35.65	6.90	7.62	....
	Kelloggs and Miller, Amsterdam, N. Y.						
5255	A. A. Cortelyou	Neshanic Station	31.82	36.70	9.28	7.88	....
	Metzger Seed and Oil Co., Toledo, O.						
5014	J. A. Lydecker	Paterson	31.75	30.00	7.14	5.00	....
5101	Carpenter and Son	Baleville	30.82	30.00	8.19	5.00	....
5102	Jaqui and Co	Morristown	32.32	30.00	7.78	5.00	....
	Mann Bros., Buffalo, N. Y.						
5230	J. V. Higgins	Flemington	34.82	35.15	7.76	6.05	....
	Milwaukee Linseed Oil Works, Milwaukee, Wis.						
5065	G. T. Freeman	Whippany	31.75	34.00	8.31	5.00	....
5164	W. H. Ingersoll	Hamburg	32.01	34.00	7.81	5.00	....
	Source Unknown.						
5298	J. H. Ashton	Trenton	33.88	34.15	7.09	6.05	....
	Average of all samples	....	34.27	32.58	7.32	5.58	....

COCOANUT CAKE.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein Found.	Protein Guaranteed.	Fat Found.	Fat Guaranteed.	Crude Fiber.
	Colby and Co., N. Y. City.						
5404	*Manufacturer	New York City	20.44	....	21.96	....	8.82
	Frank Hemingway, N. Y. City.						
5444	College Farm	New Brunswick	20.63	....	16.97	....	7.40
	Average	....	20.54	....	19.47	....	7.86

*Not an official sample.

OIL CAKE MEALS.

GERM OIL MEAL.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Glucose Sugar Refining Co., Chicago, Ill.						
5251	A. A. Cortelyou	Neshanic Station	20.87	25.50	8.77	10.50	......

CORN PRODUCTS.

CHICAGO GLUTEN MEAL.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Glucose Sugar Refining Co., Chicago, Ill.						
5084	A. N. Roe and Son	Branchville	32.18	33.00	5.51	3.00	......

FLINT OR WARREN GLUTEN FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Flint Mill Co., Milwaukee, Wis.						
5058	Mt. View Milling and Trading Co.	Mountain View	*18.25	27.00	*2.83	3.00	7.[illegible]
5149	‡ " " " " " "	" "	*18.63	27.00	*2.85	3.00	......
5392	P. J. Staats	Bound Brook	22.32	27.00	3.29	3.00	6.[illegible]
5448	‡ " "	" "	22.81	27.00	3.35	3.00	......
	Average		20.38	27.00	3.08	3.00	......

BUFFALO GLUTEN FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Glucose Sugar Refining Co., Chicago, Ill.						
5086	G. O. Young	Tranquility	24.06	27.50	3.00	2.50	......
5087	A. N. Roe and Son	Branchville	23.88	27.50	2.11	2.50	......
5193	Sharpless and Bro	Camden	22.50	27.50	2.68	2.50	......
5247	Jos. Smith and Co	Stockton	24.00	27.50	3.10	2.50	......
5248	A. A. Cortelyou	Neshanic Station	23.81	28.00	2.68	3.00	......
5349	C. C. Dempsey	Gloucester	24.94	28.00	2.82	3.00	......
5368	Peterson and Smith	Woodstown	23.13	25.50	2.98	2.50	......
5370	Fithian and Pennell	Bridgeton	24.94	25.50	2.62	2.50	......
	Average		23.85	27.13	2.68	2.65	......

†BADGER GLUTEN FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Chas. A. Krause Grain Co., Milwaukee, Wis.						
5061	C. H. Leonard	Boonton	24.82	26.00	6.01	3.00	7

* Not included in the general average.

† Made by Michigan Starch Co., Traverse City, Mich.

‡ Not an official sample.

CORN PRODUCTS.

GLOBE GLUTEN FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	New York Glucose Co., N. Y. City.						
5016	Long Dock Mills and Elevator Co..	Jersey City............	26.94	26.00	3.05	2.50	....
5042	Jos English Co	Paterson	25.75	26.00	3.85	2.50	....
5103	Jaqui and Co	Morristown	25.00	27.00	3.86	3.00	....
5138	W. S. Martin..............................	Sussex	26.83	26.00	3.28	3.00	....
5199	J. S. Collins and Son....................	Moorestown	27.44	26.00	3.54	2.50	....
5200	Sitley and Son............................	Camden..................	22.56	26.00	3.25	3.00	....
5306	L. B. Risdon Milling Co..................	Trenton..................	27.88	26.00	2.98	2.50	....
5374	A. L. Colson and Son.....................	Woodstown	26.50	26.00	3.57	2.50	....
5397	Thos. Eggert...............................	Perth Amboy.........	26.19	26.00	2.44	2.50	....
	Average	....	26.07	26.11	3.26	2.70	....

PIEL BROS.' GLUTEN FEED.

	C. W. Wagar and Co., Philadelphia, Pa.						
5312	Trenton Mills and Elevator Co	Trenton..................	27.93	27.00	2.81	3.00	6.11

WARNER'S GLUTEN FEED.

	Warner Sugar Refining Co., Waukegan, Ill.						
5189	C. A. Lippincott and Bro	Moorestown..........	23.81	27.50	5.10	3.00	....
5209	Taylor Bros................................	Camden	24.32	26.90	4.00	3.50	....
5353	J. W. Colkitt and Co.....................	Mount Holly..........	23.88	27.50	5.04	3.00	....
5375	Mixner and Mickel......	Bridgeton..............	25.19	26.90	4.00	3.50	....
	Average.....................................	....	24.18	27.20	4.54	3.25	....

MISCELLANEOUS GLUTEN FEEDS.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
5297	John H. Ashton...........................	Trenton	26.56	....	3.49	....	....
5052	The Bailey and Winters Co...........	Mountain View	25.48	27.00	3.21	3.00	....
5365	F. D. Duffield.............................	Elmer....................	25.57	....	3.00	....	....
5235	C. A. and T. P. Reed (Douglas)	Pennington...........	20.94	26.00	4.77	3.00	7.70
5318	Trenton Mills and Elevator Co......	Trenton	23.69	....	2.96	....	....
	Average of all Gluten Feeds,	....	24.79	26.76	3 41	2.82	....

CORN PRODUCTS.

HOMINY MEAL.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	American Hominy Co., Indianapolis, Ind.						
5004	J. C. Smith and Wallace Co.	Newark	9.82	11.48	7.08	8.50	7.58
5030	Campbell, Morrell and Co.	Passaic	9.82	9.25	6.64	6.98	6.59
5259	F. F. Lear	Lambertville	10.50	10.24	8.23	7.72	4.51
	M. F. Baringer, Philadelphia, Pa. ("Keystone").						
5150	Reeve Harden	Hamburg	9.75	10.50	5.93	7.90	2.92
	Buffalo Cereal Co., Buffalo, N. Y.						
5029	Van Winkle Grain and Prod. Co.	Paterson	10.00	10.50	7.17	8.50	3.88
5269	Vroom and Butler	Somerville	10.57	10.50	7.75	8.50	2.34
	Chapin and Co., Philadelphia, Pa. ("Green Diamond").						
5031	Jos. English Co.	Paterson	9.94	11.00	8.29	8.00	5.66
	Empire Grain and Elevator Co., Binghamton, N. Y. ("Star").						
5057	Mt. View Milling and Trading Co.	Mountain View	9.00	9.88	6.85	7.31	7.97
	Evans Milling Co., Indianapolis, Ind.						
5081	G. O. Young	Tranquility	10.82	11.00	9.13	9.00	3.73
	Hunter Bros., St. Louis, Mo.						
5552	Townsend and Ware	Columbus	9.12	11.20	6.76	7.70	7.19
	J. C. Klauder Est., Philadelphia, Pa.						
5346	C. C. Dempsey	Gloucester	9.44	10.88	6.64	8.59	1.32
	Chas. C. Ramey, N. Y. City ("Excelsior").						
5106	Carpenter and Son	Baleville	10.00	10.00	6.71	8.00	2.90
	Suffern Hunt & Co., Decatur, Ill.						
5071	C. H. Leonard	Boonton	9.69	11.02	7.88	7.70	4.50
	Taylor Bros., Camden, N. J.						
5532	J. W. Colkitt & Co.	Mount Holly	8.88	11.00	5.07	8.00	2.56
	The Toledo Elevator Co., Toledo, O.						
5018	Holly and Smith	Hackensack	9.88	10.60	7.14	8.27	5.59
5070	Jas. Gardner	Dover	10.00	10.60	8.56	8.27	6.01
5157	C. T. Mott & Co. ("Star")	Vernon	8.57	9.88	6.12	7.81	8.75
5038	P. O'Blenis	Paterson	11.19	10.60	8.40	8.27	4.15
	The United States Frumentum Co., Detroit, Mich.						
5041	Meyer and De Vogel	Paterson	9.94	10.14	7.58	8.76	4.05
5130	Decker and Simmons	Sussex	10.19	10.81	8.30	7.98	4.29
5131	W. S. Martin	"	10.50	10.00	9.39	8.00	4.51
	C. W. Wagar and Co., Philadelphia, Pa.						
5291	C. W. Russell	New Brunswick	10.43	11.00	7.21	7.00	2.07
5292	T. C. Dugan	" "	10.19	11.00	7.82	7.00	2.83
5536	T. S. Page and Co.	Columbus	10.00	10.81	7.68	8.62	2.88
	Average of all samples		9.91	10.86	7.36	8.02	4.49

CORN PRODUCTS.

CORN BRAN, OR SUGAR FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	M. F. Baringer, Philadelphia, Pa.						
5320	Townsend and Ware	Columbus	11.00	9.00	10 80	7.00	7.04
	J. S. Collins and Son, Moorestown, N. J.						
5176	J. S Collins and Son (Blowings)	Moorestown	10.88	....	4.71	....	8.70
	Glucose Sugar Refining Co., Chicago, Ill.						
5088	G. O. Young	Tranquility	12.07	11.00	2.51	2.92	12.13
5089	A. N. Roe and Son	Branchville	12.25	18.00	2.62	8.00	11.66
5090	R. V. Northrup	Augusta	10.69	18.00	2.93	3.00	12.40
5133	The L. S. Iliff Co	Newton	12.87	18.00	2.56	3.00	12.17
5135	Lawrence and Harden	Sussex	*18.75	13.00	4.44	8.00	9.44
5252	Worman's Mills	Frenchtown	9.25	13.00	2.66	8.00	18.35
	Average of all samples		11.34	12.60	3.00	2.98	11.74

CEREALINE FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	C. W. Wagar and Co., Philadelphia, Pa.						
5185	J. S. Collins and Son	Moorestown	9.32	7.00	7.78	5.00	8.95

GERMALINE.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Pratt Cereal Oil Co., Chicago, Ill.						
5241	C. A. and T. P. Reed	Pennington	12.82	12.90	2.60	1.29	4.84

MAIZELINE FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	C. W. Wagar and Co., Philadelphia, Pa.						
5186	C. A. Lippincott and Bro	Moorestown	9.94	10.42	9.08	9.03	7.73
5210	E. Hollingshead	"	9.19	18.99	7.41	6.07	8.10
5289	C. W. Russell	New Brunswick	9.19	10.42	7.88	9.00	6.95
5303	Trenton Mills and Elevator Co	Trenton	8.44	10.42	7.56	7.00	9.25
5387	T. S. Page and Co	Columbus	9.50	10.42	8.95	9.08	8.36
	Average		9.25	11.15	8.08	8.03	8.08

DISTILLERY AND BREWERY PRODUCTS.

BILES' FOUREX GRAINS.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	The J. W. Biles Co., Cincinnati, O.						
5241	A. A. Cortelyou	Neshanic Station	29.69	33.00	13.94	11.00	10.76
5819	Townsend and Ware	Columbus	29.06	33.00	10.76	11.00	13.04
	Average		29.38	33.00	12.35	11.00	11.90

*Not included in the average as it contained gluten meal, probably an accidental admixture.

DISTILLERY AND BREWERY PRODUCTS.

AJAX FLAKES.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Chapin & Co., Philadelphia, Pa.						
5054	The Bailey and Winters Co.	Mountain View	26.87	33.00	11.60	12.00	13.94
5078	Carpenter and Son	*Baleville*	32.82	33.00	14.75	12.00	12.27
5424	Stults Bros.	Trenton	27.25	33.00	13.10	12.00	11.90
	Average	....	28.98	33.00	13.15	12.00	12.70

MANHATTAN STOCK FOOD.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Chapin & Co., Philadelphia, Pa.						
5077	Jaqui and Co	Morristown	31.12	33.00	17.27	12.00	10.34

MERCHANTS' FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Chapin & Co., Philadelphia, Pa.						
5408	*Manufacturer	Philadelphia, Pa.	31.00	30.00	12.97	....	11.55

CONTINENTAL GLUTEN FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Continental Cereal Co., Peoria, Ill.						
5822	T. S. Page and Co	Columbus	29.69	35.00	11.56	12.50	11.52

CLIMAX DISTILLERS' GRAINS.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Deutsch and Sickert Co., Milwaukee, Wis.						
1670	College Farm	New Brunswick	34.59	....	11.54	....	10.60

"N" DISTILLERS' GRAINS.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Hotelet and Co., Milwaukee, Wis.						
5407	*Manufacturer	*Milwaukee, Wis.*	*24.06*	*24.10*	*10.15*	*6.90*	12.28

PROTEINO CORN DISTILLERS' GRAINS.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	C. F. Keck and Co., Milwaukee, Wis.						
5446	*Manufacturer	Milwaukee, Wis.	33.75	....	10.08	....	9.75

*Not an official sample.

DISTILLERY AND BREWERY PRODUCTS.

*EAGLE CORN DISTILLERS' GRAINS.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN.		FAT.		Crude Fiber.
			Found.	Guaranteed.	Found.	Guaranteed.	
	Chas. A. Krause Grain Co., Milwaukee, Wis.						
5324	D. H. Rigg	Columbus	20.63	28.00	9.31	10.00	15.43

MALT SPROUTS.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein Found.	Protein Guaranteed.	Fat Found.	Fat Guaranteed.	Crude Fiber.
	American Malting Co., Buffalo, N. Y.						
5116	G. O. Young	Tranquility	22.93	25.00	2.15	1.56	....
5265	J. B. Hill	Hopewell	24.68	25.00	2.11	2.00	....
	P. Ballantine and Sons, Newark, N. J.						
5212	J. V. Higgins	Flemington	29.50	25.00	1.75	2.00	....
	H. V. Burns, Buffalo, N. Y.						
5089	Meyer and De Vogel	Paterson	25.43	....	1.77	....	....
	Deutsch and Sickert Co., Milwaukee, Wis.						
5082	Jos. English Co	Paterson	28.94	25.00	2.33	2.00	....
5129	Decker and Simmons	Sussex	24.69	25.00	2.60	2.00	....
5246	Jos. Smith and Co	Stockton	30.06	25.00	1.76	2.00	....
5328	D. H. Rigg	Columbus	29.06	25.00	1.91	2.00	....
	H. C. Edwards, Chicago, Ill.						
5202	Taylor Bros	Camden	28.00	28.84	1.65	1.56	....
5348	J. W. Colkitt and Co	Mount Holly	26.56	28.84	2.09	1.56	....
	F. K. Fish, N. Y. City.						
5086	P. O'Blenis	Paterson	25.87	28.06	1.09	0.46	....
	Hancock and Co., Philadelphia, Pa.						
5286	C. A. and T. P. Reed	Pennington	25.25	28.20	2.09	1.70	....
5343	C. H. Kirby	Medford	23.19	28.00	2.88	1.00	....
	Hollister, Chase and Co., N. Y. City.						
5010	J. A. Lydecker	Paterson	28.69	25.00	1.85	2.00	....
5059	Mt. View Milling and Trading Co.,	Mountain View	27.07	25.00	3.01	2.00	....
	Hottelet and Co., Milwaukee, Wis.						
5288	C. A. and T. P. Reed	Pennington	26.18	....	1.60	....	....
	C. F. Keck and Co., Milwaukee, Wis.						
5805	L. B. Risdon Milling Co	Trenton	23.44	26.50	1.50	1.76	....
	E. P. Mueller, Milwaukee, Wis.						
5198	Sitley and Son	Camden	24.50	25.19	2.09	0.67	....
	Henry Rang and Son, Chicago, Ill.						
5307	Trenton Mills and Elevator Co	Trenton	24.69	26.20	1.92	1.11	....

* Made by American Spirits Mfg. Co., Peoria, Ill.

DISTILLERY AND BREWERY PRODUCTS.

MALT SPROUTS—Continued.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	John Rankin, Chicago, Ill.						
5141	*Hart* and Iliff	Newton	28.69	26.85	2.84	1.17	....
	M. G. Rankin and Co., Milwaukee, Wis. ("Jersey").						
5167	W. H. Ingersoll	Hamburg	27.56	25.00	2.08	2.50	....
5218	J. P. Hoffman	Hackettstown	25.68	25.00	1.85	2.50	....
	A. N. Roe and Son, Branchville, N. J.						
5108	A. N. Roe and Son	Branchville	28.50	28.72	1.75	1.80	....
	E. F. Seybolt, Washingtonville, N. Y.						
5046	Campbell, Morrell and Co	Passaic	25.94	26.20	2.50	1.11	....
	C. W. Wagar and Co., Philadelphia, Pa.						
5388	T. S. Page and Co	Columbus	25.69	23.50	2.15	2.00	....
	Average of all samples	....	26.09	25.15	1.99	1.65	....

DRIED BREWERS' GRAINS.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Anheuser-Busch Co., St. Louis, Mo.						
5119	Jaqui and Co	Morristown	24.88	25.00	7.69	7.00	....
5146	C. T. Mott and Co.	Vernon	28.82	25.00	8.25	7.00	....
5169	J. S. Collins and Son	Moorestown	28.56	25.00	6.32	7.00	....
5281	T. C. Dugan	New Brunswick	29.12	28.82	7.48	7.20	....
5300	L. B. Risdon Milling Co	Trenton	22.25	25.00	7.55	7.00	....
5315	H. A. Ford	Allentown	25.87	25.00	7.59	7.00	....
	M. F. Baringer, Philadelphia, Pa.						
5192	E. Hollingshead	Moorestown	28.63	28.24	6.88	7.64	....
5321	A. R. Ashby	Burlington	28.94	25.00	7.67	7.00	....
5342	Townsend and Ware	Columbus	24.50	25.00	7.85	7.00	....
	Farmers' Feed Co., N. Y. City.						
5082	G. O. Young	Tranquility	24.25	24.30	8.91	7.00	....
	F. W. Goeke, St. Louis, Mo.						
5091	G. O. Young	Tranquility	23.82	24.86	7.35	5.69	....
	Hancock and Co., Philadelphia, Pa.						
5329	Hutchinson Bros	Crosswicks	27.38	26.19	7.19	6.00	....
	Hottelet and Co., Milwaukee, Wis. ("Holstein").						
5239	C. A. and T. P. Reed	Pennington	34.50	30.20	7.17	4.10	....
5275	J. B. Hill	Hopewell	33.94	30.20	8.18	4.10	....
	J. C. Klander Est., Philadelphia, Pa.						
5177	C. A. Lippincott and Bro	Moorestown	28.25	28.00	7.18	7.00	....
5256	Worman's Mills	Frenchtown	24.88	28.00	7.38	7.00	....
5331	T. S. Page and Co.	Columbus	23.69	23.00	7.15	7.00	....
5344	J. W. Colkitt and Co.	Mount Holly	25.12	28.00	7.15	7.00	....
5345	C. H. Kirby	Medford	21.00	28.00	6.85	7.00	14.99

DISTILLERY AND BREWERY PRODUCTS.

DRIED BREWERS' GRAINS—Continued.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN.		FAT.		Crude Fiber.
			Found.	Guaranteed.	Found.	Guaranteed.	
	Gottfried Krueger, Newark, N. J.						
5396	P. J. Staats	Bound Brook	28.00	23.71	7.31	7.80	....
	Wm. J. Lemp Brewing Co., St. Louis, Mo.						
5162	A. B. Albert	Danville	28.25	25.00	7.91	7.00	....
	E. P. Mueller, Milwaukee, Wis.						
5163	W. H. Ingersoll	Hamburg	27.94	*32.00	6.77	....	....
5196	Sitley and Son	Camden	27.19	*32.00	7.85	....	....
	Penn Grains and Feed Co., Philadelphia, Pa.						
5203	Taylor Bros	Camden	27.87	23.24	7.90	7.64	....
5378	Sheard and Brooks	Vineland	29.50	23.30	7.91	4.97	....
5380	Mixner and Mickel	Bridgeton	27.88	23.24	7.83	7.64	....
	Chas. C. Ramey, N. Y. City.						
5105	Carpenter and Son	Baleville	24.38	22.24	7.53	7.01	....
5140	The L. S. Iliff Co	Newton	27.94	22.24	7.63	7.01	....
	M. G. Rankin and Co., Milwaukee, Wis. ("Durham").						
5068	G. T. Freeman	Whippany	28.38	25.00	6.67	7.00	....
5217	J. P. Hoffman	Hackettstown	28.62	25.00	7.29	7.00	....
	C. W. Wagar and Co., Philadelphia, Pa.						
5277	Mundy Brothers	Bound Brook	28.44	23.82	7.88	7.20	....
5290	C. W. Russell	New Brunswick	24.44	23.82	7.61	7.20	....
5314	Trenton Mills and Elevator Co	Trenton	21.68	23.82	7.04	7.20	....
	Source Unknown.						
5364	F. D. Duffield	Elmer	25.43	....	6.94	....	....
5377	Hires and Co	Quinton	22.44	23.30	7.56	4.97	16.18
5201	Sharpless and Bro	Camden	21.44	22.13	6.35	4.30	17.41
	Average of all samples	....	25.71	24.91	7.35	6.71	....

MOLASSES GRAINS AND FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein Found.	Protein Guaranteed.	Fat Found.	Fat Guaranteed.	Crude Fiber.
	Deutsch and Sickert Co., Milwaukee, Wis.						
5362	A. L. Colson and Sons (Grains)	Woodstown	22.07	19.00	8.79	2.50	8.81
	E. P. Mueller, Milwaukee, Wis.						
5197	Sitley and Sons (Grains)	Camden	15.19	20.25	3.48	2.26	12.63
5205	Taylor Bros. "	"	20.94	18.00	4.84	2.57	9.57
5066	Jaqui and Co. (Feed)	Morristown	17.00	*28.00	4.60	....	11.31
	Average of all samples	....	18.80	19.08	4.18	2.44	10.58

* Protein and fat.

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FEED MIXTURES.

CANADA OAT FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN.		FAT.		Crude Fiber.
			Found.	Guaranteed.	Found.	Guaranteed.	
	American Cereal Co., Chicago, Ill.						
5193	E. Hollingshead	Moorestown	5.88	5.00	2.64	2.50	24.29

QUAKER DAIRY FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein Found.	Protein Guaranteed.	Fat Found.	Fat Guaranteed.	Crude Fiber.
	American Cereal Co., Chicago, Ill.						
5110	G. O. Young	Tranquility	12.75	14.00	3.88	3.50	17.91
5211	J. P. Hoffman	Hackettstown	12.19	14.00	3.89	3.50	17.62
5415	S. Anderson	Hammonton	12.93	14.00	3.89	3.50	15.70
	Average		12.62	14.00	3.89	3.50	17.08

SCHUMACHER'S STOCK FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein Found.	Protein Guaranteed.	Fat Found.	Fat Guaranteed.	Crude Fiber.
	American Cereal Co., Chicago, Ill.						
5002	C. B. Demarest	Hackensack	12.56	13.00	4.98	5.00	8.64
5121	The L. S. Iliff Co.	Newton	11.88	13.00	5.84	5.00	7.85
5418	E. C. Norton	Hightstown	12.56	13.00	4.67	5.00	8.58
	Average		12.33	13.00	5.00	5.00	8.36

VICTOR CORN AND OAT FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein Found.	Protein Guaranteed.	Fat Found.	Fat Guaranteed.	Crude Fiber.
	American Cereal Co., Chicago, Ill.						
5008	Miller and Bertholf	Jersey City	8.68	9.00	4.86	4.00	10.77
5279	Runyon Bros	New Brunswick	8.87	9.00	4.46	4.00	11.01
5293	J. H. Ashton	Trenton	8.44	9.00	4.58	4.00	11.83
	Average		8.66	9.00	4.63	4.00	11.04

VIM OAT FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein Found.	Protein Guaranteed.	Fat Found.	Fat Guaranteed.	Crude Fiber.
	American Cereal Co., Chicago, Ill.						
5118	A. N. Roe and Son	Branchville	7.50	7.50	3.72	2.75	21.44
5341	J. W. Colkitt & Co	Mount Holly	5.50	7.50	2.89	2.75	23.94
	Average		6.50	7.50	3.31	2.75	22.69

SUCRENE DAIRY FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein Found.	Protein Guaranteed.	Fat Found.	Fat Guaranteed.	Crude Fiber.
	American Milling Co., Chicago, Ill.						
5316	Townsend and Ware	Columbus	16.56	16.50	5.11	3.50	12.19
5299	L. B. Risdon Milling Co.	Trenton	17.56	16.50	4.48	3.50	11.28
5145	Reeve Harden	Hamburg	16.91	16.50	4.61	3.50	10.70
5282	C. W. Russell	New Brunswick	15.75	16.50	3.86	3.50	12.08
	Average		16.70	16.50	4.50	3.50	11.55

FEED MIXTURES.

SUCRENE HORSE FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude Fiber.
	American Milling Co., Chicago, Ill.						
5119	A. N. Roe and Son	Branchville	14.56	13.50	3.99	3.50	9.64
5124	The L. S. Iliff Co.	Newton	13.18	13.50	4.35	3.50	10.06
	Average		13.65	13.60	4.17	3.50	9.85

BILES' READY RATION (Union Grains).

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude Fiber.
	The J. W. Biles Co., Cincinnati, O.						
5245	A. A. Cortelyou	Neshanic Station	21.94	24.00	7.44	7.00	9.22
5450	*J. F. Sharpe	Blairstown	25.75	24.00	7.18	7.00	....
	Average		23.85	24.00	7.31	7.00	....

BLOMO FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude Fiber.
	The Blomo Mfg. Co., N. Y. City.						
5285	C. W. Russell	New Brunswick	13.56	15.00	1.26	1.19	9.26
5301	Trenton Mills and Elevator Co	Trenton	19.69	15.00	1.60	1.19	11.08
5390	T. E. Capner	South Amboy	18.75	15.00	1.56	1.19	9.83
	Average		17.33	15.00	1.47	1.19	10.04

BUFFALO CORN AND OAT CHOP.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude Fiber.
	Buffalo Cereal Co., Buffalo, N. Y.						
5273	Vroom and Butler	Somerville	9.32	8.00	4.46	4.00	11.28
5387	T. E. Capner	South Amboy	9.50	8.00	4.76	4.00	9.67
	Average		9.41	8.00	4.61	4.00	10.48

BUFFALO CREAMERY FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude Fiber.
	Buffalo Cereal Co., Buffalo, N. Y.						
5271	Vroom and Butler	Somerville	17.50	20.00	4.78	5.00	10.85
5388	Van Zant and Voorhees	Plainfield	20.37	20.00	4.67	5.00	9.77
	Average		18.94	20.00	4.73	5.00	10.31

BUFFALO HORSE FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude Fiber.
	Buffalo Cereal Co., Buffalo, N. Y.						
5389	Van Zant and Voorhees	Plainfield	11.94	12.00	4.59	4.50	7.37
5270	Vroom and Butler	Somerville	11.82	12.00	5.41	4.50	7.05
	Average		11.88	12.00	5.00	4.50	7.21

* Not an official sample.

FEED MIXTURES.

DE FI CORN AND OAT FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Elsworth and Co., Buffalo, N. Y.						
5425	The J. E. Stevenson Co.	Trenton	9.25	8.30	3.84	3.00	12.39

EMPIRE FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Empire Mills, Olean, N. Y.						
5007	Union Coal and Feed Co.	Hackensack	7.69	7.63	3.55	2.97	8.87

HOLSTEIN SUGAR FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	F. W. Goeke, St. Louis, Mo.						
5092	A. N. Roe and Son	Branchville	12.75	15.23	3.33	3.27	9.95
5093	R. V. Northrup	Augusta	14.00	15.23	3.65	3.27	8.80
5156	Reeve Harden	Hamburg	15.43	15.23	3.66	3.27	7.53
	Average		14.06	15.23	3.54	3.27	8.76

BOSS CORN AND OATS FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Great Western Cereal Co., Chicago, Ill.						
5005	Miller and Bertholf	Jersey City	8.44	9.00	4.92	4.00	11.82
5287	Runyon Bros	New Brunswick	8.75	9.00	5.29	4.00	10.97
	Average		8.60	9.00	5 11	4.00	11 40

EXCELSIOR CORN AND OAT FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Great Western Cereal Co., Chicago, Ill.						
5132	The L. S. Iliff Co.	Newton	9.12	9.00	6.92	4.20	10.08

FRIENDS' OAT FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Great Western Cereal Co., Chicago, Ill.						
5304	Trenton Mills and Elevator Co.	Trenton	5.25	8.00	2.38	3.00	25.67
5327	Hutchinson Bros.	Crosswicks	6.50	8.00	2.82	3.00	23.92
	Average		5.88	8.00	2.60	3.00	24 80

ROYAL OAT FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Great Western Cereal Co., Chicago, Ill.						
5009	Wilkinson, Gaddis and Co.	Newark	6.82	7.60	2.48	2.80	24.24
5037	Meyer and De Vogel	Paterson	5.75	7.60	2.88	2.80	24.99
5220	J. S. Wiseburn	Junction	6.19	7.60	3.16	2.80	23.41
5328	H. A. Ford	Allentown	5.68	7.60	1.72	2.80	25.48
	Average		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

FEED MIXTURES.

H. O. DAIRY FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	The H. O. Co., Buffalo, N. Y.						
5096	Jaqui and Co.	Morristown	18.00	18.00	5.18	4.50	10.80
5395	Thos. Eggert	Perth Amboy	19.06	18.00	5.07	4.50	8.90
	Average		18.53	18.00	5.13	4.50	9.85

H. O. HORSE FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	The H. O. Co., Buffalo, N. Y.						
5371	J. K. Waddington	Salem	12.50	12.00	3.52	4.50	8.16
5394	Jos. Benedict	Elizabeth	12.81	12.00	5.79	4.50	8.27
5430	The J. E. Stevenson Co	Trenton	12.88	12.00	4.14	4.50	8.57
	Average		12.40	12.00	4.48	4.50	8.33

MONARCH CHOP FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Husted Milling and Elev. Co., Buffalo, N. Y.						
5011	Union Coal and Feed Co	Hackensack	9.25	8.09	5.49	4.16	8.74
5136	W. S. Martin	Sussex	8.75	8.09	4.58	4.16	10.04
	Average		9.00	8.09	5.04	4.16	9.39

PROTENA DAIRY FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Purina Mills, St. Louis, Mo.						
5447	* Manufacturer	St. Louis, Mo	19.00	20.00	4.70	3.50	19.42

NUTRO GLEN.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	The L. B. Risdon Milling Co., Trenton, N. J.						
5308	Manufacturer	Trenton	19.57	21.00	4.52	4.50	7.60

CRACKERJACK DAIRY FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Taylor Bros., Camden, N. J.						
5204	Taylor Bros.	Camden	28.81	30.62	18.95	12.00	7.15

CORNELIA DAIRY FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Trenton Mills and Elevator Co., Trenton, N. J.						
5309	Manufacturer	Trenton	20.69	24.19	4.66	6.05	5.78

* Not an official sample.

FEED MIXTURES.

IMPERIAL DAIRY FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	C. W. Wagar and Co., Philadelphia, Pa.						
5311	J. H. Ashton	Trenton	10.18	8.74	3.74	2.81	15.30
	SUNDRY OAT FEEDS.						
	H. C. Edwards, Chicago, Ill.						
5048	Van Winkle Grain and Prod. Co	Paterson	7.69	5.68	4.20	2.06	20.87
	Hancock and Co., Philadelphia, Pa.						
5287	C. A. and T. P. Reed	Pennington	7.87	4.40	3.61	2.10	18.84
	MISCELLANEOUS FEEDS.						
	BARLEY FEED.						
	P. C. Kamm and Co., Milwaukee, Wis.						
5062	Mt. View Milling and Trading Co.	Mountain View	13.56	13.13	3.85	4.00	9.19
	Pioneer Cereal Co., Akron, O.						
5166	A. B. Albert	Danville	14.63	15.00	3.68	4.61	9.53
	M. G. Rankin and Co., Milwaukee, Wis. ("Crown").						
5069	G. T. Freeman	Whippany	12.56	....	3.07	....	8.99
	Allen V. Smith, Marcellus Falls, N. Y.						
5020	J. C. Smith and Wallace Co	Newark	13.25	14.90	3.95	3.40	10.85
	Average		13.50	14.34	3.64	4.00	9.49
	DRIED BEET PULP.						
	Alma Sugar Co., Alma, Mich.						
5115	Jaqui and Co	Morristown	8.06	8.50	0.58	0.59	16.00
	IMPERIAL STOCK FOOD (from Sugar Beets).						
	Bay City-Mich. Sugar Co.						
5028	Van Winkle Grain and Prod. Co	Paterson	7.93	8.56	0.45	0.59	17.70
	PEANUT BRAN.						
	The Phœnix Milling Co., Petersburg, Va.						
5410	*Manufacturer	Petersburg, Va	5.50	9.12	1.68	1.75	65.05

*Not an official sample.

MISCELLANEOUS FEEDS.

PEANUT MIDDLINGS.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	The Phœnix Milling Co., Petersburg, Va.						
5411	** Manufacturer*	*Petersburg, Va.*	*8.07*	*13.00*	2.71	4.21	47.86

RICE FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Deutsch and Sickert Co., Milwaukee, Wis.						
5405	* Manufacturer	Milwaukee, Wis.	6.50	......	4.57	......	22.79
	P. H. Van Waggoner and Co., N. Y. City.						
5438	W. N. Steward	Englishtown	7.25	9.56	4.10	12.65	23.62
	Average		6.88	......	4.34	......	23.21

POULTRY FOODS.

AMERICAN POULTRY FOOD.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	American Cereal Co., Chicago, Ill.						
5422	E. C. Norton	Hightstown	18.44	14.00	5.96	4.50	4.44

BUFFALO POULTRY FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	Buffalo Cereal Co., Buffalo, N. Y.						
5272	Vroom and Butler	Somerville.	17.18	17.00	5.00	5.00	5.87

H. O. POULTRY FOOD.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	The H. O. Co., Buffalo, N. Y.						
5194	J. S. Middleton	Camden	16.00	17.00	5.77	5.50	4.77
5330	H. A. Ford	Allentown	15.63	17.00	5.17	5.50	5.62
	Average		15.82	17.00	5.47	5.50	5.20

H. AND L. POULTRY FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	C. A. Lippincott and Bro., Moorestown, N. J.						
5178	Manufacturer	Moorestown	20.94	18.00	7.98	8.50	5.84

ANIMAL MEAL AND CALF MEAL.

ANIMAL MEAL.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	The Bowker Co., Boston, Mass.						
5268	*Vroom and Butler*	*Somerville*	*40.81*	*39.00*	*16.66*	*5.00*	......

BLATCHFORD'S CALF MEAL.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.
	J. W. Barwell, Waukegan, Ill.						
[illegible]	C. W. Russell	New Brunswick	28.28	26.00	4.85	5.00	......

LOCAL FEED MIXTURES

REQUIRING GUARANTEE.

Station Number.	MANUFACTURER.	INGREDIENTS.	PROTEIN. Found.	PROTEIN. Calculated.	FAT. Found.	FAT. Calculated.	Crude Fiber.
5147	A. B. Albert, Danville	Corn meal, barley feed, wheat middlings	11.82	12.5	1.98	4.2	3.86
5266	W. N. Adair and Co., Raritan	Oats, corn, wheat screenings	9.88	10.6	2.51	3.9	8.30
5075	[1]Belvidere Flouring Mill Co., Belvidere		10.38	9.8	3.68	2.4	4.62
5034	Jos. English Co., Paterson	Hominy, Royal oats, rye feed	9.69	10.1	5.82	6.4	8.81
5158	Reeve Harden, Hamburg (No. 1)	Hominy, rye middlings, ground oats, ship stuff, corn meal	11.81	12.1	5.05	6.8	7.27
5159	Reeve Harden, Hamburg (No. 2)	Hominy, Royal oats, rye middlings, ship stuff	10.18	11.1	5.07	6.2	9.34
5161	W. H. Ingersoll, Hamburg (Hercules)		11.88	10.0	5.24	5.0	5.55
5099	Jaqui and Co., Morristown (No. 1)	Corn, oats, hominy	9.19	10.5	3.90	5.8	3.58
5100	Jaqui and Co., Morristown (No. 2)	Corn meal, hominy, Quaker oats	9.69	10.9	3.90	5.8	5.55
5347	C. H. Kirby, Medford (Dairy feed)		18.25	18.18	3.65	2.86	9.24
5063	C. H. Leonard, Boonton	Hominy, Vim oats, red dog, brown middlings	11.07	12.7	5.58	6.1	9.10
5181	G. K. and O. H. McMurtrie, Belvidere		10.50	10.0	3.51	3.0	3.10
5242	C. A. and T. P. Reed, Pennington (Dairy feed)	Wheat bran, gluten feed, corn meal, C. S. meal, oil meal, wheat middlings	17.25	19.1	4.55	4.6	5.37
5019	J. C. Smith and Wallace Co., Newark	Hominy, Royal oats, corn meal,	10.50	9.7	3.95	6.6	5.05
5416	[2]Taylor Bros., Camden (No. 2 Dairy feed)		11.82	12.76	3.82	3.08	3.91
5047	Van Winkle Grain and Produce Co., Paterson (No. 2)	Hominy, oat feed, brown middlings	11.38	11.1	7.11	7.0	4.25
5276	Vroom and Butler, Somerville	Buffalo corn and oats, hominy	9.94	9.5	6.09	6.3	5.32
5024	Wilkinson, Gaddis and Co., Newark	Corn meal, Royal oats, oat hulls	8.88	8.2	3.56	3.7	3.86
5072	[3]Jacob S. Wiseburn, Junction		7.81	....	1.78	.....	7.09
5261	Worman's Mills, Frenchtown	Corn bran, rye, corn, oats, brewers' grains	11.88	12.0	4.25	5.1	5.52
	Average		10.85	11.36	4.84	4.97	5.69

[1] Stock of Hart and Iliff, Newton.
[2] " " Geo. Elvins, Hammonton.
[3] " " Jas. Gardner, Dover.

WHEAT.

WINTER WHEAT BRAN.

Station Number.	MANUFACTURER OR JOBBER.	PLACE OF SAMPLING.	Protein.	Fat.	Crude Fiber.
5243	Ballard and Ballard Co., Louisville, Ky	Everittstown	14.82	3.71	5.99
5326	H. A. Ford, Allentown, N. J.	Allentown	15.81	3.91	8.08
5018	*Kingfisher Mill and Elev. Co.*, Kingfisher, *Okl.*	Newark	16.81	4.48	6.74
5435	C. H. Snyder and Son, Freehold, N. J.	Freehold	14.32	4.77	8.38
5487	H. E. Taylor, Englishtown, N. J.	Englishtown	15.00	4.79	7.59
5141	Thompson and Mould, Goshen, N. Y.	Sussex	16.38	4.64	6.41
5381	D. R. Worman, Philadelphia, Pa	Quinton	16.68	5.06	7.57
	Average		15.47	4.48	7.54
	SPRING WHEAT BRAN.				
5372	Hancock and Co., Philadelphia, Pa	Elmer	12.81	5.27	9.58
5225	W. J. Jennison Co., Minneapolis, Minn	Flemington	13.44	4.96	10.86
5015	M. and M. M. Co., Rochester, N. Y.	Newark	16.25	5.67	8.44
5258	National Milling Co., Minneapolis, Minn. ("Hardenbergh's")	Neshanic Station	14.12	5.15	9.28
	Pillsbury Flour Co., Minneapolis, Minn	Flemington	15.44	5.14	9.27
5045	Rochester City Mills, Rochester, Minn	Ridgewood	14.12	4.96	7.88
5431	Royal Milling Co., Minneapolis, Minn. ("Ben Hur")	Hightstown	12.81	4.71	10.80
5333	Star and Crescent Milling Co., Chicago, Ill	Wrightstown	13.88	5.08	10.88
	Average		14.05	5.12	9.56
	BLENDED WHEAT BRAN.				
5175	Belvidere Flouring Mill Co., Belvidere, N. J.	Belvidere	14.87	4.71	9.02
5183	G. K. and O. H. McMurtrie, Belvidere, N. J.	"	16.07	4.36	7.21
	Average		15.47	4.54	8.11
	WHEAT MIDDLINGS.				
5073	Ballard and Ballard Co., Louisville, Ky. ("Ship Stuff")	Baleville	15.81	4.94	6.31
5053	Chapin and Co., Philadelphia, Pa.	Rockaway	17.69	5.28	2.53
5222	G. C. Higgins and Son, Three Bridges, N. J.	Three Bridges	13.63	3.28	1.76
5180	G. K. and O. H. McMurtrie, Belvidere, N. J. ("White")	Belvidere	14.32	3.53	1.73
5054	Pillsbury Flour Co., Minneapolis, Minn. ("B")	Passaic	15.57	5.48	8.17
5434	C. H. Snyder and Son, Freehold, N. J. ("Shorts")	Freehold	15.66	3.91	2.82
5021	Washburn-Crosby Co., Minneapolis, Minn. ("Standard")	Newark	15.75	5.82	6.97
5188	Washburn-Crosby Co., Minneapolis, Minn. ("Flour")	Moorestown	15.86	4.98	4.43
5234	Jacob S. Wiseburn, Junction, N. J. ("White")	Junction	15.60	3.48	1.81
	Average		15.41	4.52	3.96
	FEEDING FLOUR.				
5023	Dwight Flour Mills, Minneapolis, Minn. ("Red Dog")	Passaic	18.44	3.51	....
5143	Sleepy Eye Milling Co., Sleepy Eye, Minn	Sussex	14.75	3.25	....
5187	Washburn-Crosby Co., Minneapolis, Minn. ("[illegible]")	Moorestown	16.94	4.70	....

WHEAT—RYE.

WHEAT FEED.

Station Number.	MANUFACTURER OR JOBBER.	PLACE OF SAMPLING.	Protein.	Fat.	Crude Fiber.
5114	American Cereal Co., Chicago, Ill. ("Buckeye")[1]	Tranquility	15.69	5.16	9.80
5278	" " " " " "	New Brunswick	13.56	4.66	8.47
5419	" " " " " "	Hightstown	13.81	4.58	7.76
5401	*Acme Milling Co., Indianapolis, Ind. ("Acme")	Indianapolis, Ind	14.94	4.62	8.33
5126	M. F. Baringer, Philadelphia, Pa. (Bulk)	Sussex	13.94	4.58	8.33
5127	" " " " (Bags)	"	17.44	5.22	7.58
5149	" " " " (Bulk)	Hamburg	16.94	5.01	6.88
5076	Blish Milling Co., Seymour, Ind	Baleville	16.69	4.92	7.42
5402	*Seymour Carter, Hastings, Minn. ("Croesus")	Hastings, Minn	16.88	5.25	7.83
5128	Chapin and Co., Philadelphia, Pa	Sussex	15.13	4.56	7.72
5158	" " " " " ("Valier's")	Hamburg	15.25	4.62	6.70
5080	Chas. M. Cox and Co., Boston, Mass. ("Eagle Fancy Soft Winter")	Tranquility	13.13	4.15	9.87
5406	*The Hannibal Mill Co., Hannibal, Mo. ("Empire Crown")	Hannibal, Mo	14.44	4.86	7.86
5408	*Indiana Milling Co., Terre Haute, Ind. ("Jersey")[2]	Terre Haute, Ind	†11.82	3.50	15.09
5137	F. L. Kidder and Co., Paris, Ill	Newton	†10.31	3.94	13.63
5226	Louisville Milling Co., Louisville, Ky. ("Eat-more")	Clinton	17.56	4.71	8.03
5409	*R. P. Moore Milling Co., Princeton, Ind. ("King")	Princeton, Ind	15.88	4.82	6.55
5189	Chas. C. Ramey, N. Y. City	Newton	15.57	4.76	7.54
5107	Rex Milling Co., Kansas City, Mo. ("Rex")	Branchville	14.63	4.85	7.50
5142	" " " " " " "	Sussex	15.18	4.66	6.98
5168	" " " " " " "	Hamburg	15.88	4.85	7.07
5109	Waggoner-Gates Mill. Co., Independence, Mo	Branchville	17.00	5.14	7.54
5412	*A. Waller and Co., Henderson, Ky. ("Blue Grass")[3]	Henderson, Ky	†10.57	2.79	16.64
	Average		15.48	4.77	7.79

WHEAT AND RYE MIDDLINGS.

5173	Belvidere Flouring Mill Co., Belvidere, N. J	Belvidere	12.81	2.75	1.23

RYE BRAN.

5384	J. N. Smith and Bro., Pemberton, N. J	Pemberton	14.00	3.72	3.18
5310	Trenton Mills and Elevator Co., Trenton, N. J	Trenton	15.69	3.45	3.28
	Average		14.85	3.59	3.23

RYE FEED.

5148	M. F. Baringer, Philadelphia, Pa	Hamburg	14.82	3.52	4.01
5086	Jos. English Co., Paterson, N. J	Paterson	13.44	2.65	2.58
5427	C. E. Hall, Adelphia, N. J	Adelphia	‡10.06	1.87	1.21
5335	J. N. Smith and Bro., Pemberton, N. J	Pemberton	‡9.82	1.96	1.85
5483	W. N. Steward, Englishtown, N. J	Englishtown	‡9.75	1.96	1.30
	Average		14.13	3.09	3.30

* Not an official sample. [1] Guaranteed 17.75 protein and 4.70 fat.

CORN MEAL.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	Protein.	Fat.	Crude Fiber.
5267	W. N. Adair and Co., Raritan	Raritan	†7.69	2.28	....
5151	[1] Belvidere Flouring Mill Co., Belvidere	Danville	8.88	3.88	....
5259	Barton Hoffman, Ringoes	Ringoes	8.07	3.84	2.64
5098	Jaqui and Co., Morristown ("Bolted")	Morristown	9.12	4.15	....
5231	E. V. Parry, Clinton	Clinton	8.69	3.72	....
5023	Wilkinson, Gaddis and Co., Newark	Newark	8.81	3.67	....
	Average		8.71	3.88	....

WHOLE GRAINS GROUND TOGETHER.

CORN AND OATS.

5386	[2] T. Amerman, South Branch	Elizabeth	9.75	3.26	5.35
5391	P. S. Dayton and Co., Plainfield	Plainfield	10.00	3.37	3.00
5257	F. F. Lear, Lambertville	Lambertville	9.12	4.10	3.47
5439	[3] Wilkinson, Gaddis & Co., Newark	Red Bank	8.88	3.12	3.22
	Average		9.44	3.46	3.76

MISCELLANEOUS GRAINS.

5221	J. V. Higgins, Flemington	Corn, oats, rye	8.88	3.14	2.70
5233	Pursell Milling and Coal Co., Phillipsburg	Corn, oats, rye	8.75	4.68	8.89
	Average		8.82	3.91	5.79

*CRACKED RICE.

5413	Penn Grains and Feed Co., Philadelphia, Pa	Philadelphia, Pa.	7.44	0.58	....

*CORN WHEAT.

5417	Johnson and Stokes, Philadelphia, Pa	Philadelphia, Pa	12.06	1.92	....

* Not an official sample. † Not included in the average; contains 21.93 per cent. water.

[1] A. B. Albert.

[2] The Hildebrant Co.

[3] L. E. Brown.

BUCKWHEAT PRODUCTS.

BUCKWHEAT MIDDLINGS.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	SOLD AS	Protein.	Fat.	Crude Fiber.
5215	Nelson Dufford, Hackettstown	Bran	32.69	9.34	8.81
5179	G. K. and O. H. McMurtrie, Belvidere	Middlings	31.19	9.24	2.96
5214	Warren Beaty, Hackettstown	"	30.88	9.22	1.78
5442	[1] R. Stephens Co., Bartley	Bran	30.41	8.10	4.22
5228	J. P. Larison, Washington	"	30.13	8.83	7.43
5400	[2] Ellis and Moore, Candor, N. Y.	"	29.50	8.11	7.12
5064	Miller and Mott, Rockaway	Middlings	29.50	8.76	5.50
5262	Worman's Mills, Frenchtown	Bran	29.38	8.40	4.09
5174	Belvidere Flouring Mill Co., Belvidere	Middlings	28.75	8.26	2.20
5260	Jos. Smith and Co., Stockton	Feed	27.38	7.62	5.00
5254	Joseph Huff, Everittstown	Bran	27.19	8.28	6.41
5213	Warren Beaty, Hackettstown	"	27.06	7.15	12.47
5227	J. P. Larison, Washington	Middlings	27.00	7.65	1.37
	Average		29.31	8.34	4.95

BUCKWHEAT BRAN.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	SOLD AS	Protein.	Fat.	Crude Fiber.
5056	[3] Nelson Dufford, Hackettstown	Bran	28.44	6.11	7.81
5216	" " "	Middlings	22.07	6.86	0.81
5228	L. L. Holcombe, Flemington	"	21.44	6.18	2.74
5229	G. G. McPherson, Lebanon	"	20.50	5.88	3.28
5263	Worman's Mills, Frenchtown	"	20.06	6.04	1.67
5160	W. H. Ingersoll, Hamburg	"	19.68	6.05	1.27
5383	Wolff Bros., Hainesburg	"	19.38	4.54	3.50
1667	[4] Jas. W. Spence, N. Y. City	"	19.36	4.59	2.17
	Average		20.74	5.71	2.91

BUCKWHEAT FEED.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	SOLD AS	Protein.	Fat.	Crude Fiber.
5382	Wolff Bros., Hainesburg	Feed	17.75	4.72	15.39
5182	G. K. and O. H. McMurtrie, Belvidere	Bran	*9.69	2.67	26.88
5132	[5] Jas. W. Spence, N. Y. City	"	19.19	4.15	14.81
	Average		18.47	4.44	15.10

[1] J. L. Hope, Madison.
[2] G. W. Tuttle, Bernardsville.
[3] Jas. Gardner, Dover.
[4] College Farm, New Brunswick.
[5] W. N. Stewart, Englishtown.
* Not included in the average.

II.

MARKET PRICES OF COMMERCIAL FEEDS.

Kind of Feed.	Average for the Six Months Preceding— May 1, 1902.	May 1, 1903.	May 1, 1904.	May 1, 1905.
Cottonseed Meal	30.79	29.85	29.87	29.25
Linseed Meal	35.50	32.27	30.71	32.44
Chicago Gluten Meal	29.50	31.00	....	31.00
Germ Oil Meal	26.50	24.00	26.00	30.00
Gluten Feeds	27.30	25.81	25.73	25.46
Hominy Meal	27.77	25.62	23.89	24.88
Maizeline Feed	26.75	26.50	24.91	26.00
Cerealine Feed	27.69	24.86	....	24.00
Corn Bran, or Sugar Feed	21.15	20.17	21.73	22.13
Corn Meal	28.95	....	24.62	25.48
Corn and Oats (Provender)	29.69	28.57	23.83	25.48
Royal Oat Feed	19.50	16.57	16.60	16.08
Vim Oat Feed	20.58	15.60	16.00	17.00
Wheat Feed	25.75	22.26	23.18	24.59
Wheat Bran	25.95	22.12	22.64	24.31
Wheat Middlings	28.75	25.28	26.71	26.71
Feeding Flour	28.33	27.40	27.75	29.13
Rye Bran	23.00	....	....	22.00
Rye Middlings	25.00	24.25	....	26.00
Rye Feed	25.25	24.36	....	25.00
Buckwheat Middlings	22.00	20.40	22.50	21.12
Buckwheat Bran	20.00	18.67	18.05	21.43
Buckwheat Feed	....	15.00	16.00	....
Barley Feed	....	26.00	25.00	24.63
Dried Distillers' Grains	21.67	18.50	23.67	25.57
Malt Sprouts	21.37	18.69	19.19	21.08
Dried Brewers' Grains	22.73	20.06	21.21	22.72
Molasses Grains	....	20.50	20.71	20.88
Boss Corn and Oat Feed	23.50	22.30	22.60	22.00
De Fi Corn and Oat Feed	25.00	....	....	25.00
Excelsior Corn and Oat Feed	....	25.00	25.00	25.00
H. O. Dairy Feed	29.00	29.33	29.00	29.50
H. O. Horse Feed	29.99	30.00	29.33	29.17
Sucrene Dairy Feed	26.00	....	....	24.00
Monarch Chop Feed	26.00	25.00	23.00	23.67
Quaker Dairy Feed	24.56	20.44	22.78	23.67
Schumacher's Stock Feed	30.75	28.67	26.20	26.60
Victor Corn and Oat Feed	25.61	22.90	22.55	22.86
Blomo Feed	....	....	28.00	26.33
Dried Beet Pulp	....	....	18.50	22.00

CONDIMENTAL FEEDS AND CONDITION POWDERS.

BY JOHN PHILLIPS STREET.

For many years various condimental feeds and condition powders have been offered for sale to the feeders of farm stock. The virtues and the failings of these preparations have been discussed many times by various investigators in this country and Europe, and their excessive cost and the doubtful benefits attendant upon their use clearly pointed out, yet their number, and the feeders using them, seem to have been constantly increasing. An examination of the publications of the various Experiment Stations in this country shows that, together with those reported herewith, 126 different brands have been found on the American markets. Of these sixteen were reported in two States, four in three, and eighteen in more than three States, the balance being reported but once. This would indicate that only a small proportion of the total number meet with a general sale throughout the country, the great bulk being confined to a rather limited local market. This bulletin contains twenty-three brands, whose analysis has not been previously reported by any Experiment Station, and as comparatively few of the Stations have made a thorough inspection of these preparations, the total number on our markets is probably much in excess of that given above.

The increasing use of these materials led this Station in its 1904 inspection to collect all the different brands its inspector could find on the New Jersey market; as a result fifty different brands were found. A comprehensive microscopical and chemical analysis has been made of all of these, the chemical analysis, including the determination of the various food compounds present, as well as a more or less complete analysis of the ash ingredients, including phosphoric acid, potash, lime, chlorin, sulphuric acid, magnesia, soda, iron, carbonic acid, nitric acid and insoluble matter.

Relation of Condimental Feeds to the Feeding Law.

While under a strict interpretation of the State Feeding law, many of these feeds, especially those which directly or indirectly claim to possess a food value, could be included under its provisions and would

require a guarantee, the Station has never insisted upon guarantees being furnished, feeling that such a guarantee would be meaningless and of little value. These feeds are not sold or purchased with any thought of the value of their constituent feeds, but rather of the medicinal properties of the drugs and condiments which are added. A guarantee of protein and fat on feeds selling from $250 to $700 per ton could serve no useful purpose. Accordingly, we find but one of the feeds examined which is guaranteed as to its protein and fat content.

The Composition of Condimental Feeds.

The condimental feeds generally consist of some well-known feeding material, like linseed meal, wheat feed or corn meal, as a base, to which have been added varying amounts of vegetable or mineral drugs, ground bone, oyster shells, or some make-weight.

The range of materials used is very wide, as the following summary will show:

Feeding Stuffs.	Vegetable Drugs.	Mineral Drugs.
Linseed meal.	Fenugreek.	Common salt.
Wheat feed.	Gentian.	Glauber's salt.
Wheat bran.	Fennel.	Epsom salts.
Corn meal.	Ginger.	Carbonate of soda.
Cottonseed meal.	Turmeric.	Phosphate of lime.
Barley.	Anise.	Carbonate of lime.
Rye.	Senna.	Saltpetre.
Oats.	Asafœtida.	Oxide of iron.
Rice.	Black pepper.	Copperas.
Gluten feed.	Cayenne.	Antimony.
Malt sprouts,	Elecampane root.	Alum.
Rape seed.	Blood root.	Rosin.
Millet seed.	Juniper berries.	Charcoal.
Flaxseed meal.	Licorice root.	
Lentils.	Coriander seed.	Miscellaneous.
Cob meal.	Valerian.	Meat.
Bean meal.	Lobelia.	Ground bone.
	Mandrake root.	Dried blood.
	Sage.	Oyster shells.
	Oak bark.	Limestone.
	Bayberry bark.	Silicate of alumina.
	Poplar bark.	Weed seeds.
	Walnut bark.	Mustard hulls.
	Hemp.	Cocoa shells.
	Ground herbs.	Linseed husks.
		Sand.

Medicinal Properties of Drugs Employed.

The purpose of the use of drugs in these mixtures in most cases is to create an appetite, to tone up the system or to act as a corrective on the bowels of the animal, omitting for the present the consideration of their "cure-all" properties, as claimed by their manufacturers. Some of the drugs above named are well-known remedies, and are doubtless in more or less constant use by all careful stockmen. The following tabulation, taken from Bulletin No. 144, of the Virginia Experiment Station, shows the action of these drugs and the usual dose of the same for a horse:

Name.	Action.	Dose for Horse.
Common salt	Restorative, stomachic and antiseptic	
Saltpetre	Diuretic, febrifuge	½ to 1 ounce.
Sulphur	Alterative and laxative	½ to 4 ounces.
Iron	Tonic	
Ginger root	Stimulant	½ to 2 ounces.
Fenugreek	Condiment, aromatic and stimulant	1 to 2 "
Fennel seed	Condiment, aromatic and stimulant	1 to 2 "
Glauber's salt	Cathartic, diuretic and febrifuge	½ lb. to 1½ lbs.
Gentian	Tonic	½ to 1 ounce.
Senna leaves	Laxative and diuretic	1 to 4 ounces.
Alum	Astringent	2 to 4 drachms.
Cayenne	Stimulant	¼ to ½ "
Oak bark	Astringent	2 to 4 "
Lime	Antacid	1 to 2 "
Soda	Antacid and alterative	1 to 2 "
Mustard	Stimulant, irritant, stomachic	4 to 6 "
Anise seed	Aromatic stimulant	1 to 2 ounces.
Epsom salts	Purgative, alterative, febrifuge	½ to 1½ pounds.
Chlorate of potash	Alterative, diuretic, expectorant	1 to 4 drachms.
Charcoal	Absorbent, antiseptic, deodorant	½ to 1 ounce.
Rosin	Gentle stimulant, astringent, diuretic	2 to 4 ounces.

The careful compounding of a condimental feed should require sufficient knowledge of the drugs employed to avoid using those which, by their action, would prevent the full effect of others. Drugs of contrary or opposite properties, therefore, should not be used together, or the effect of each will be lost. An examination of the tables of analysis will show that in certain cases the manufacturer has compounded his mixtures, regardless of the properties of the drugs used, and that frequently, instead of a scientific formula, as is generally claimed, the feed is rather a heterogeneous mixture of drugs of opposing properties and of doubtful efficacy for the ailments specified.

The Claim of the Manufacturers.

Keeping in mind the fact that by far the greater number of these preparations consist very largely of some ordinary feed like linseed meal, wheat feed or corn meal, with the addition of small amounts of various drugs, it is of interest to note the claims the manufacturers put forth for their products.

One condition powder claims to purify the blood, create a good appetite, regulate the system and give a fine, glossy, soft skin. It is a sure cure for distemper, dyspepsia, dropsy, coughs, colds, bots or worms, colic, pink-eye, epizootic and influenza in horses; milk fever, garget and pleuro-pneumonia in cattle; gapes, worms, fever, roup and cholera in chickens, besides increasing their egg-laying power; it is also successful with children for worms or fits. It consists chiefly of corn, wheat, linseed and cottonseed meals, with a little sodium chlorid and fenugreek added.

A stock food claims to be "a product of science prepared by graduates of medicine, pharmacy and veterinary." It cures all diseases of horses, besides acting as a tonic to the sexual organs of stallions; prevents loss of cud, bloat, flatulence, and cures diarrhœa, constipation and rheumatism in cattle, is invaluable during pregnancy and prevents abortion; it also cures all diseases of swine. This material consists of wheat feed and corn, with sodium chlorid, lime, Glauber's salt and charcoal added.

A poultry food claims to be "a scientific combination of pure, wholesome materials. * * * In the saving of grain it will repay its cost several times over. In winter it imparts warmth to the body, healthy activity to all organs and supplies the needed material for egg-making. * * * Chickens will feather earlier, develop much sooner, with larger growth and stronger bone, and will always be better winter layers. * * * It is unexcelled for all poultry diseases. * * * Perhaps its greatest value is in keeping the flock free from diseases." It consists of linseed meal, wheat, sulphur, oyster shells, cayenne, charcoal, salt, magnesia, sulphate and iron oxid.

It is unnecessary to give further examples of the claims made for these feeds, as the instances given are typical. One thing is very noticeable in all the preparations, whether specifically for horses, cattle, swine or poultry, and that is, that they are sure cures for all diseases of the respective animals, and in some cases the same claim is even made for all diseases of all farm animals. In considering these claims, it must be remembered that, except in a very few instances, the great bulk of these feeds are made up of materials other than medicines, and that if the directions for their use are followed, using from one to three tablespoonsful two or three times a day, and sometimes even less, the animal will receive only an infinitesimal amount of the intended remedy. The prescribed doses of these various drugs, according to the best veterinary practice, are from five

to ten times greater than could possibly be obtained by following the manufacturers' directions, and that such a method of treatment could be effective in the cure of any one disease, not to say all diseases, is certainly a tax on the credulity of the purchaser. Further, as has been pointed out above, the drugs used often counteract each other. It can be easily understood how a certain drug might be administered which would ensure a healthy and well-ordered working of the digestive processes of an animal, but how the same medicine could *cure* both constipation and diarrhœa is difficult of comprehension; and yet this is claimed by the stock food just referred to. Such apparent contradictions are frequent, not only in the claims made for the feeds, but also in the ingredients, shown to be present by means of microscopical and chemical analysis. It is evident, therefore, that these claims, when not absurd, are excessive and misleading, and are no more worthy of credence than similar claims made for the numerous brands of patent medicines made for the human animal.

Selling Price of the Feeds.

Even if the condimental feeds fulfilled the claims made for them, the excessive prices charged would, with very few exceptions, be an argument against their general use. Although a few of these feeds are sold by the bag, or even by the ton, the great majority—all but three of those examined—are sold in small packages, ranging in weight from one-half to twelve and one-half pounds, at prices ranging from ten cents to $1 per package. It is true that in many cases large packages can be purchased at comparatively lower prices, but even then the prices are still very high. For instance, one feed, which is sold at twenty-five cents for a pound and a half package, sells for $6 per 100 pounds, an exceedingly high price. In order to avoid the very excessive prices of these feeds, when calculated on the ton basis, and in order to secure an equitable basis of comparison, in the tables which follow are given the actual weight of the package, the price per package and the cost per pound. The packages vary greatly in weight and price, and in many cases the weight sold and the price asked seems to have little relation. When considered, even on the pound basis, the variations are very striking, ranging, as they do, from 6.0 to 36.3 cents per pound, or from $6 to $36.30 per hundred.

The following tabulation shows the wholesale price per pound of the principal drugs used in these mixtures, as quoted in the *Oil, Paint and Drug Reporter* of January 16th, 1905:

	Price per pound. Cents.		Price per pound. Cents.
Epsom salts	1 to 1.3	Ginger root	8 to 9
Sulphur	1.9 to 2	Fenugreek	2.25 to 2.5
Common salt	0.5 to 0.75	Fennel seed	5 to 5.25
Saltpetre	3.9 to 4	Gentian root	4 to 4.5
Oxide of iron	0.75 to 2	Senna leaves	9 to 11
Glauber's salt	0.5 to 0.6	Aniseed	5 to 5.25
Alum	1.7 to 1.8	Asafœtida	18 to 22
Lime	1 to 1.5	Juniper berries	1.75 to 2
Sodium bicarbonate	1.3 to 1.7	Ground flaxseed	3.25 to 3.5

It will be observed that, with the exception of asafœtida, which is very sparingly used in compounding these mixtures, the price per pound ranges from 0.5 to 11 cents; in other words, if the condimental feed consisted solely of drugs, its cost would range from 50 cents to $11 per hundred. As a matter of fact, seldom more than twenty per cent., and usually much less of these feeds, consists of drugs, so that the added cost of the drugs, with rare exceptions, would not exceed from 10 cents to $2.20 per hundred. A few illustrations will show how the addition of a little salt and an aromatic or appetizing drug to an ordinary commercial feed increases its value in the eyes of its compounder.

One of the poultry tonics is shown to consist very largely of wheat feed, to which has been added salt, oyster shells, saltpetre, Glauber's salt, iron oxid, and probably asafœtida. The protein content of this product, 9.69 per cent., would seem to indicate that about two-thirds of the mixture consisted of the wheaten material. The addition of thirty-three pounds of drugs to sixty-seven pounds of wheat feed, however, has caused the mixture to sell at the rate of $19.50 per hundred, while the best wheat feed can be purchased in our markets at the present time at $1.20 per hundred retail; in other words, the thirty-three pounds of drugs added have cost the consumer $18.70 per hundred.

Another condition powder consists chiefly of wheat feed, with oats, sulphur, saltpetre and Epsom salts added. It contains 14.9 per cent. protein and but 9.1 per cent. ash, showing that a very small amount of mineral drugs had been added—probably less than 5 per

cent. This small quantity of drugs, however, has been sufficient to raise the price of the wheat feed from $1.20 to $36.30 per hundred, a charge of $35.16 per hundred being made for the drugs.

Another sample, a stock food, consists of wheat feed and corn meal, to which have been added salt, linseed meal, Glauber's salt, carbonate of lime, saltpetre, charcoal, sulphur, rosin and a little iron. The amount of ash, 20.5 per cent., shows that the added drugs make up about one-sixth of the mixture. The price of the wheat and corn in this sample has been raised from $1.20 to $18.10 per hundred, a charge of $17.10 per hundred being made for the drugs.

Still another sample consists of an inferior wheat product, and salt, carbonate of lime, Epsom salts, carbonate of soda, fenugreek and rosin. The feed portion of this mixture is largely make-weight, as the sample contains but 5.6 per cent. protein and is practically worthless. It contains 52.4 per cent. ash, over 37 per cent. being common salt. Thus we have a sample one-half of matter of low feeding value, one-third common salt and the remainder drugs of more or less value; its cost is $12.60 per hundred. The purchaser of this material practically bought common salt, adulterated with a wheat product and common drugs, and instead of paying the market price of 50 cents per hundred for salt, paid $12.10 per hundred additional for what was in reality an adulterated article.

These illustrations, chosen at random, are typical of nearly all the materials under consideration, and show most clearly that purchasers of them pay a very excessive price for the supposed skill used in compounding them. As will be shown in another section of this bulletin, the Station does not in any way detract from the usefulness and value of many of the constituent remedies used by the compounders of condimental feeds, but it cannot state too emphatically its belief that when an animal is in need of treatment, medicines should be used under the competent and wise direction of a skilled veterinarian, or according to methods which the feeder's experience has shown to be efficacious. Good and satisfactory results cannot hope to be secured when a hit-or-miss policy is adopted, or when the good, common sense of the feeder is temporarily supplanted by the specious claims of these patent medicines. Even granting that the efficiency of these mixtures was beyond all question of doubt, the feeder who wishes to maintain his business on strict economic principles cannot afford to experiment with condimental feeds.

Feeding Experiments with Condimental Feeds.

The claims for the efficiency of these feeds have been so persistent that a number of the Experiment Stations have conducted feeding tests in which they formed a part of the ration. An examination of the literature of the subject shows that at least sixteen feeding experiments of this nature have been carried out with various kinds of farm animals and testing the merits of a number of the better known condimental feeds. A brief summary of these follows:

In a test with dairy cows at the Kansas Station,[1] eight cows produced 212 pounds more milk and 17.4 pounds more butter-fat in a month from a ration containing Acme Stock Food than from one not containing the condimental feed. The cost per pound of the butter-fat, however, increased from 12.3 to 14.6 cents. In a test at the same Station with Globe Stock Food, the added condimental feed, with the same number of animals and for the same period, produced 6.8 pounds more butter-fat and 112 pounds less milk, a pound of butter-fat costing 11.7 instead of 11 cents. The experimenter concluded that they "are worthless for dairy cows accustomed to a good, balanced ration."

Plumb[2] experimented on eight pigs, feeding shorts and hominy feed with and without American Stock Food. The total gain of the lot with the condimental feed was 682 pounds; that without, 689 pounds, while the cost of producing one pound of gain with the condimental was 3 cents, and without, 2.6 cents. Another experiment with pigs, where Rauh's Stock Food and Standard Stock Food were used with a ration of corn meal and shorts, showed that where the stock feeds were used 387 pounds were gained; where they were not used, 366 pounds. The writer, in his conclusions, stated that there was no special objection to stock feeds, except their excessive price—that oil meal alone would often give quite as good results and that feeders should make their own stock feeds, and thus avoid paying high prices for feeds of an unknown character.

Clothier,[3] in a test with 211 sheep, using alfalfa hay and ear-corn with and without a condimental feed, found that the sheep not fed the condimental gained 117 pounds more than those which received it.

Snyder and Hummel[4] found that steers digested alfalfa hay fed with corn meal much more thoroughly than a similar ration with condimental feed added.

In an experiment at the Iowa Station[5] in fattening young hogs, Standard Stock Food with corn gave ten per cent. greater profit than corn fed alone.

Hills[6] fed Nutriotone to seven cows and concluded that "the material does not appear to have increased productiveness in this particular experiment."

Bartlett[7] fed Nutriotone to cows. "In neither of these cases did Nutriotone seem to have any effect, favorable or unfavorable. The slightly smaller flow with Nutriotone does not mean anything in particular, except to add increased emphasis to the falseness of the claim that two large tablespoonsful fed with each feed will produce a great increase of much richer milk."

[1] Kansas Expt. Stat., Bull. 119.
[2] Indiana Expt. Stat., Bull. 93.
[3] Industrialist, Vol. 26 (1900), p. 469.
[4] Minnesota Expt. Stat., Bull. 80.
[5] Iowa Expt. Stat., Bull. 65.
[6] Vermont Expt. Stat., 8th Rept., p. 150.
[7] Maine Expt. Stat., 12th Rept., pp. 51-55.

Sir John Lawes,[1] after making a thorough test, wrote: "In conclusion, I feel bound to say that I should require much clearer evidence than any that has hitherto been adduced, to satisfy me that the balance sheet of my farm would present a more satisfactory result at the end of the year were I to give each horse, ox, sheep and pig a daily allowance of one of these costly foods."

Sir John Lawes[2] also tested Thorley's Stock Food with sheep, substituting it in part for the linseed meal and cottonseed meal of the ration. "The results previously published of experiments with pigs, taken together with those now recorded in regard to sheep, seem sufficiently conclusive against the assumption that the use of the so-called condiments increases the assimilation of food by fattening animals in a state of health. They are equally conclusive on the subject of the profit or loss to the feeder from the use of such substances. Whether or not the so-called condiments may prove advantageous in the cases of old, overworked, or otherwise debilitated horses, or to fattening animals of poor constitution, or of weakly digestive power, is quite another question. In some such cases they will doubtless happen to be appropriate; but whether the beneficial results will be attained at a greater or less cost by having recourse to medicines in the ordinary way, or to the use of the so-called condiments, must be left to others to determine."

Yeo[3] states that "many of these, by conferring agreeable flavors and by their warm, carminative properties, promote appetite and assist digestion; but their excessive use is calculated to excite irritation and disorder of the digestive organs."

In an experiment with steers at the Iowa Station,[4] Iowa Stock Food with corn and wheat straw returned a profit of $1.40 per steer less than corn and wheat straw alone; International Stock Food, $8.16 less, and Standard Stock Food, $8.92 less.

Brooks[5] fed a lot of hens a mash and whole grain, with artificial grit, oyster shells and pure water always before them. One lot in addition was fed condition powders; nineteen fowls fed the powder produced 163 eggs in seventy-nine days at a cost of 2.7 cents per egg; the same number not fed the powder produced in the same time 195 eggs, at a cost of 1.8 cents per egg. Those receiving no condition powder had laid twenty-four eggs before the others began.

The same experimenter[6] tested Sheridan's Condition Powder. "A study of the figures shows that the hens not getting the condition powder laid more eggs, of practically the same average weight. The food required to produce a single egg was less, and the cost was very materially less. In the light of these results, it is believed that poultry keepers throw away money expended for condition powders."

This summary of feeding experiments shows that in thirteen of the sixteen experiments the addition of condimental feeds either had no effect at all, or was actually a detriment to the ration; while in three experiments they had a slightly favorable effect, but in each case the increase of yield was accompanied by a greatly increased cost of the product. On the other hand, the testimonials published by the manu-

[1] Jour. Roy. Agl. Soc., Eng., Vol. 19, p. 204.
[2] Rothamsted Memoirs, Vol. 2.
[3] Food in Health and Disease.
[4] Iowa Expt. Stat., Bull. 66.
[5] Mass. Expt. Stat., Rept. 1896, pp. 46–49.
[6] Mass. Expt. Stat., Rept. 1898, p. 90.

facturers indicate uniformly good and in some cases really wonderful results from their use. It is doubtless true that the great majority of these testimonials are based on the sincere belief of the users that the remedy has actually benefited his animals. It is extremely doubtful, however, if many of these testimonials were secured from careful and scientific tests. Perhaps no other kind of agricultural investigation requires so many safeguards, if reliable deductions are to be drawn therefrom, as do feeding experiments with farm animals. Uniformity of conditions, including the bodily health of the animal, its care, the work it performs, and accurate records of the food supplied and the food rejected, are of vital importance, while the individuality of the animal is always a disturbing factor. Clearly, it stands to reason that the experiments conducted under scientific supervision and with careful and painstaking attention are more deserving of credence than those carried out by farmers, who, no matter how honest may be their intentions or how unremitting may be their care, by their lack of scientific training overlook certain details necessary in any comparative experiment, and when the results of the experiments are before them are unable properly to interpret them. Wherever benefit has followed the use of condimental feeds, it was probably due to the feeding stuffs and not the medicines they contained. The increased appetite often observed from their use would probably have been obtained just as easily, and certainly at much less cost, by any rational change of diet, especially when common salt was generously supplied to the ration.

The Use of Condimental Feeds.

Animals in good health require no medicine—in fact, the excessive use of medicine with well animals frequently induces disorders. However, it often occurs that loss of appetite, stomachic derangements or overwork prevent an animal from performing its full quota of work or cause a falling off in its production of milk, butter, meat, eggs or wool. In such cases a simple remedy, like salt or linseed meal, may often be used with much benefit, and it is recommended that all animal feeders keep a supply of them on hand for these emergencies. In the case of organic or contagious diseases, a veterinarian should always be consulted, and medicines should be administered only under his supervision.

The Analysis of the Samples.

Fifty samples were analysed, of which seventeen were stock feeds, fourteen poultry feeds and nineteen condition powders or tonics; they represent the product of twenty-nine manufacturers.

Microscopical Analysis.

The microscope is the only certain means of detecting the drugs, especially those of a vegetable nature, which were used in compounding these mixtures. The detection of these vegetable drugs is attended with considerable difficulty, for in many cases they are used in very small quantities; and further, the number of drugs which might be made use of is so great that a very extensive knowledge of the histological structure of medicinal plants is necessary for their certain recognition. In some cases, too, for instance, gentian, the plants possess no markedly characteristic microscopical structure, and their certain detection in a mixture is almost impossible. It is not claimed, therefore, that the description of these feeds, which is given on subsequent pages, includes all the vegetable drugs present. It does include, however, those drugs which were used in sufficiently large quantities as to make their use a matter of importance. As regards the mineral drugs employed, it is believed that the ash analysis as made gives a practically complete record of the mineral ingredients of the feeds, although in certain cases it was difficult to determine in just what form some particular base was used.

Chemical Analysis.

Each of the samples was subjected to a complete feed analysis, as well as a detailed examination of the ash ingredients. The presence of large quantities of mineral matter, and the nature of the same, in certain samples interfered seriously with the determination of the food compounds. Twenty-one of the samples contained free sulphur, and accordingly the ether extract in these samples was contaminated with sulphur. A quantitative determination of the free sulphur was made in every case, however, by the chromyl chlorid method of Pozzi-Escot[1] and the proper correction noted. Charcoal was present

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[1] Rev. Gén. Chim.-Appl. 7 (1904), p. 240.

in fifteen samples, and it has been included in all cases under crude fiber, although a quantitative estimation was not made. The presence of large amounts of carbonic acid and free sulphur has made the ash determination in certain instances too high, as even after continued incineration carbonates and sulphates (due to the free sulphur) were found in the ash. The carbonic acid likewise in a few cases made the percentage of moisture too low and that of nitrogen-free extract too high. In the ash analysis the presence of small quantities of iron with large amounts of lime, phosphoric acid and magnesia made the methods of the Association of Official Agricultural Chemists inapplicable, and it was necessary, in part, to work out new methods. It was found that in the precipitation of iron and alumina with ammonia, where the amount of iron and alumina present was small and that of phosphate of lime was large, invariably the precipitate was contaminated with calcium phosphate. It was therefore necessary in every case to determine the phosphoric acid in the ignited residue of the iron and alumina determination in order to make the proper correction. For the same reason it was impossible to use the filtrate from the iron determination for the estimation of the lime, and new portions were used in every case for this determination.

Phosphoric acid, potash, chlorin, lime, magnesia, sulphuric acid, iron and alumina, nitric acid and acid-insoluble matter were determined in all the samples, while soda and carbonic acid were determined in about half of the samples; so that in all cases, except those marked with an asterisk, the determination was actually made.

DESCRIPTION OF THE SAMPLES.

MANUFACTURER AND BRAND.	Station Number.	PRINCIPAL INGREDIENTS.	OTHER INGREDIENTS IDENTIFIED.
Stock Feeds.			
American Stock Food, Amer. Stock Food Co., Freemont, O.	4178	*Corn meal, wheat feed, salt.*	Linseed meal, carbonate of lime, saltpetre, sulphur, rosin, charcoal, Glaub.r's salt.
Ashland Stock Food, Ashland Stock Food Co., Ashland, O.	4019	Wheat feed, corn meal, salt.	Glauber's salt, charcoal, lime.
Banner Stock Food, Banner Food Co., Auburn, N. Y.	4086	Linseed meal	Charcoal, salt, lime, saltpetre, Epsom salts.
Blatchford's Calf Meal, J. W. Barwell, Waukegan, Ill.	4116	Bean, wheat and linseed meals.	Cottonseed meal, fenugreek.
Baum's Stock Food, Baum Castorine Co., Rochester, N. Y.	4256	Linseed meal	Charcoal, sulphur, salt, Glauber's salt.
Nutriotone, W. D. Carpenter Co., Chicago, Ill.	4289	Linseed, cottonseed and bean meals.	Salt, sulphur, corn meal, charcoal, fenugreek.
International Stock Food, International Food Co., Minneapolis, Minn	4522	Wheat feed, salt	Charcoal, pepper, probably gentian.
Metropolitan Horse and Cattle Food, Metropolitan Food Co., N. Y. City.	4087	Cottonseed meal, wheat, salt	Linseed meal, fenugreek, Epsom salts.
Pratt's Food for Horses and Cattle, Pratt Food Co., Philadelphia, Pa.	4527	Corn meal, wheat feed	Bean meal, salt, fenugreek, Epsom salts.
Royal Stock Food, Royal Co-operative Mfg. Co., Indianapolis, Ind	4828	Wheat feed, linseed meal.	Magnesian limestone, charcoal, copperas, saltpetre.
California Horse and Cattle Food, H. B. Sherman & Sons, Long Branch, N. J.	4421	Wheat feed	Pepper, carbonate of soda.
Simpson's Stock Food, Simpson Grain and Food Co., Norristown, Pa.	4330	Corn meal, wheat feed	Salt, charcoal, lime, Epsom salts, copperas.
Triplex Stock Food, Triplex Food Co., New Brunswick, N. J.	4545	Wheat bran	Salt, lime, fenugreek.
Wilbur's Stock Food, Wilbur Stock Food Co, Milwaukee, Wis.	4011	Wheat, linseed meal	Salt, charcoal.
Young's Anti-Abortion Food, Young's Food Co., Media, Pa.	4276	Wheat feed, ground bone.	*Alumina, limestone, possibly turmeric.
Young's Hog Food, Young's Food Co, Media, Pa	4320	Wheat feed, linseed meal.	Lime, iron oxid, Epsom salts.
" Horse Food, " " " " "	4322	Wheat feed	Corn meal, sulphur, salt, lime, saltpetre, Epsom salts.

DESCRIPTION OF THE SAMPLES—Continued.

MANUFACTURER AND BRAND.	Station Number.	PRINCIPAL INGREDIENTS.	OTHER INGREDIENTS IDENTIFIED.
Poultry Foods.			
American Poultry Food, American Stock Food Co., Fremont, O	4179	Wheat feed, corn meal	Linseed meal oyster shells, pepper, salt, *alumina, Epsom salts.
Ashland Poultry Food, Ashland Stock Food Co., Ashland, O	4021	Wheat, oats, corn	Oyster shells, salt, iron oxid, Epsom salts.
Blatchford's Poultry Meats, J. W. Barwell, Waukegan, Ill.	4585	Blood, meat, bone, oyster shells.	Ginger, iron oxid, Epsom salts.
Baum's Poultry Food, Baum Castorine Co., Rochester, N. Y.	4473	Linseed meal, wheat feed	Sulphur, iron oxid, charcoal, pepper, salt, oyster shells, Epsom salts.
International Poultry Food, International Food Co., Minneapolis, Minn.	4449	Wheat feed	Pepper, charcoal, fenugreek, gentian, iron oxid, Epsom salts.
Lee's Egg Maker and Chick Grower, Geo. H. Lee Co., Omaha, Neb.	4180	Linseed meal, blood, salt	Sulphur, lime, saltpetre, Glauber's salt.
Pratt's Poultry Food, Pratt Food Co, Philadelphia, Pa.	4040	Wheat feed, corn	Gentian, sulphur, pepper, iron oxid, Epsom salts.
Puritan Chick Food, The Puritan Farms and Mfg. Co., Stamford, Conn	4089	Corn meal, wheat feed	Lime.
Rochester Poultry Food, Rochester Horse and Cattle Food Co., Rochester, N. Y.	4237	Wheat feed	Blood, corn, sulphur, mica, lime.
Rust's Egg Producer, Wm. Rust and Sons, New Brunswick, N. J.	4543	Ground bone, oyster shells, millet seed	*Alumina, pepper, sulphur.
Simpson's Poultry Food, Simpson Grain and Food Co., Norristown, Pa.	4829	Corn meal, blood	Oyster shells, sulphur, iron oxid, Glauber's salt, fibrous woody material.
Triplex Poultry Food, Triplex Food Co, New Brunswick, N. J.	4544	Wheat feed, bone, oyster shells	*Alumina, pepper, charcoal, sulphur.
Wilbur's Egg and Poultry Food, Wilbur Seed Meal Co., Milwaukee, Wis.	4010	Wheat feed	Cottonseed meal, fenugreek, magnesian limestone, salt, iron oxid.
Young's Poultry Food, Young's Food Co., Media, Pa.	4821	Wheat feed, linseed meal	Bone, sulphur, Epsom salts.

* Probably as hydrated silicate of alumina.

DESCRIPTION OF THE SAMPLES—Continued.

MANUFACTURER AND BRAND.	Station Number.	PRINCIPAL INGREDIENTS.	OTHER INGREDIENTS IDENTIFIED.
Condition Powders and Tonics.			
Barker's Vegetable Horse, Cattle and Poultry Powder, Barker, Moore and Mein Medical Co., Phila., Pa.	4872	Linseed meal	Salt, sulphur, lime, charcoal, iron oxid, Epsom salts, gentian.
Fairfield's Blood Tonic and Milk Producer, Fairfield Mfg. Co., Philadelphia, Pa.	4878	Common salt, wheaten material	Carbonate of lime, Epsom salts, carbonate of soda, fenugreek, ros n.
Fairfield's Hog Tonic, Fairfield Mfg. Co., Philadelphia, Pa.	4467	Wheat, corn	Charcoal, sulphur, salt, copperas, carbonates of lime and soda, Epsom salts.
Fairfield's Poultry Tonic, Fairfield Mfg. Co., Philadelphia, Pa	4468	Wheat feed, blood	Limestone, pepper, sulphur, Epsom salts.
Weston's Condition Powder, Robert Ferrett, N. Y. City	4048	Corn meal, wheat feed	Linseed meal, cottonseed meal, fenugreek, salt.
Harvell's Condition Powder, Dr. Herrick's Family Medicines, N. Y. City	4422	Wheat feed, saltpetre	Linseed meal, aniseed, fennel, lime, Glauber's salt, Epsom salts.
Hess' Poultry Panacea, Dr. Hess and Clark, Ashland, O	4181	Wheat feed, salt	Oyster shells saltpetre, iron oxid, Glauber's salt, possibly asafœtida.
Rancocas Horse and Cattle Powder, Mt. Holly Stock Food Co., Mt. Holly, N. J	4825	Wheat, oats	Sulphur, saltpetre, Epsom salts.
Rancocas Poultry Powder, Mt. Holly Stock Food Co., Mt. Holly, N. J.	4826	Wheat feed	Sulphur, Epsom salts, Glauber's salt, probably senna.
Myers' Royal Horse and Cattle Spice, Myers', Niagara, Falls, N. Y.	4824	Corn meal, linseed meal, salt	Mustard hulls pepper, lime, turmeric, fenugreek, Epsom salts.
Myers' Royal Poultry Spice, Myers', Niagara Falls, N. Y.	4328	Corn meal, wheat feed	Linseed meal, mustard hulls, pepper, fenugreek, salt, turmeric, lime, Epsom salts.
Our Own Condition Powder, Peterson and Smith, Woodstown, N. J.	4875	Linseed meal	Lime, iron oxid, Epsom salts, undetermined greenish-black material.
Pratt's Animal Regulator, Pratt Food Co, Philadelphia, Pa.	4374	Corn meal	Salt, charcoal, gentian, fennel, Epsom salts.
Royal Poultry Mixture, Royal Coöperative Mfg Co., Indianapolis Ind.	4327	Magnesian limestone	Iron oxid.
Haven's Climax Condition Powder, Wm. Rust and Sons, New Brunswick, N. J.	4542	Millet seed, linseed meal	Pepper, sulphur, lime, Epsom salts.

DESCRIPTION OF THE SAMPLES—Continued.

MANUFACTURER AND BRAND.	Station Number.	PRINCIPAL INGREDIENTS.	OTHER INGREDIENTS IDENTIFIED.
Condition Powders and Tonics—Continued.			
Shuster's Poultry Powder, E. H. Shuster Co., Woodbury, N. J.	4539	Wheat and gluten feeds	Carbonates of lime and soda, sulphur, possibly Glauber's salt.
Shuster's Condition Powder, E. H. Shuster Co., Woodbury, N. J.	4538	Linseed meal, corn, wheat	Sulphur, lime, Glauber's salt.
Sturtevant's Poultry Cure, F. C. Sturtevant, Hartford, Conn.	4541	Wheat feed	Ground bone, oyster shells, *alumina, salt, Glauber's salt.
Sturtevant's Medicated Meal, F. C. Sturtevant, Hartford, Conn	4540	*Linseed meal, wheat feed*	*Salt, sulphur, lime, fenugreek, gentian, ginger.*

*Probably as hydrated silicate of alumina.

Discussion of Analyses.

The feeds examined have been divided somewhat arbitrarily into three classes according to their brand name; accordingly we have stock feeds, poultry feeds and condition powders and tonics. The analyses indicate that, although there are wide variations in the different groups, the average feed analysis of the three classes is very similar:

	Protein. Per cent.	Ash. Per cent.
Average, stock feeds	16.41	17.18
Average, poultry feeds	18.03	20.33
Average, condition powders and tonics	17.32	20.20

The protein varies from 9.32 to 24.50 per cent. in the stock feeds, from 9.38 to 35.63 per cent. in the poultry feeds, and from none at all to 34.38 per cent. in the condition powders; in the first class the ash varies from 4.82 to 51.18 per cent., in the second from 6.45 to 61.27 per cent., and in the third from 6.19 to 99.46 per cent. It is evident from these figures that the brand name signifies little as to the adaptability of the feed to the class of animals for which it is recommended. Much the same choice of materials is shown in the compounding of the mixtures of all three classes, although ground bone and oyster shells are used more generally in the poultry mixtures. Only fourteen of the samples contain over 20 per cent. protein, while twenty contain less than fifteen per cent.; the claim, therefore, generally made that these mixtures are highly concentrated feeds is not, as a rule, justified by the facts.

CONDIMENTAL STOCK FOODS.

Feed Analysis.

Station Number.	BRAND.	Water.	Ether Extract.	Crude Fiber.	Protein.	Ash.	Nitrogen-free Extract.	Weight of Package.	Price of Package.	Cost per Pound.
		%	%	%	%	%	%	gms.	cts.	cts.
4178	American Stock Food	10.30	[1]4.08	4.51	[5]14.69	20.54	45.66	626	25	18.1
4019	Ashland Stock Food	12.18	2.28	5.88	10.63	21.59	47.44	1809	25	8.7
4086	Banner Stock Food	11.16	6.45	12.29	[6]20.38	14.86	34.98	....	....	....
4116	Blatchford's Calf Meal	10.82	4.66	4.33	24.00	4.82	51.87	....	....	....
4256	Baum's Stock Food	11.54	[2]7.48	16.89	24.50	13.61	26.08	....	....	....
4289	Carpenter's Nutriotone	6.87	[3]6.60	5.45	19.69	20.60	40.79	907	50	25.0
4522	International Stock Food	6.91	4.05	18.19	18.07	20.36	42.42	1180	50	19.2
4037	Metropolitan Horse and Cattle Food	9.41	5.35	8.33	23.19	31.77	21.95	2338	50	9.7
4527	Pratt's Food for Horses and Cattle	7.27	6.54	7.67	14.06	7.10	57.36	5443	75	6.3
4828	Royal Stock Food	9.50	2.40	11.23	[8]15.81	7.34	54.03	464	25	24.4
4421	Sherman's California Horse and Cattle Food	10.68	2.48	2.06	10.50	15.96	58.33	5669	75	6.0
4830	Simpson's Stock Food	12.95	3.32	7.94	9.32	17.72	48.75	956	25	11.9
4545	Triplex Stock Food	9.25	4.32	2.27	13.00	8.21	62.95	3175	50	7.1
4011	Wilbur's Stock Food	9.28	6.75	6.21	16.06	11.35	50.35	648	25	17.5
4276	Young's Anti-Abortion Food	8.28	1.68	2.19	23.38	51.18	13.39	2268	100	20.0
4820	" Hog Food	8.12	3.99	5.54	15.50	10.84	56.01	2268	75	15.0
4822	" Horse Food	7.00	[4]9.39	8.72	[7]11.69	14.71	52.80	814	25	13.9

[1] 0.91 per cent. free sulphur. [3] 0.68 per cent. free sulphur. [5] Contains also 0.44 per cent. nitrogen as nitrates.
[2] 0.50 " " " " [4] 1.46 " " " " [6] " " 0.19 " " " " "
[7] " " 0.69 " " " " "
[8] " " 0.27 " " " " "

CONDIMENTAL POULTRY FOODS.

Feed Analysis.

Station Number.	BRAND.	Water.	Ether Extract.	Crude Fiber.	Protein.	Ash.	Nitrogen-free Extract.	Weight of Package.	Price of Package.	Cost per Pound.
		%	%	%	%	%	%	gms.	cts.	cts.
4179	American Poultry Food	9.08	3.69	4.23	14.51	23.89	44.60	635	25	17.9
4020	Ashland Poultry Food	11.77	2.16	3.25	9.88	19.26	54.18	748	25	15.2
4585	Blatchford's Poultry Meats	5.80	8.45	5.05	30.69	26.83	23.18	1824	25	6.2
4478	Baum's Poultry Food	8.21	[1]9.41	10.65	17.87	21.03	32.83	882	25	12.9
4449	International Poultry Food	10.14	5.31	10.17	15.50	6.45	52.43	610	25	18.6
4180	Lee's Egg Maker and Chick Grower	6.68	[2]4.08	9.29	[9]35.63	26.32	17.65	1081	25	11.0
4040	Pratt's Poultry Food	11.62	[3]8.24	4.45	13.57	6.16	55.96	228	10	19.9
4089	Puritan Chick Food	9.90	6.33	3.75	12.56	7.64	59.82	2268	35	7.0
4287	Rochester Poultry Food	10.15	[4]5.63	12.92	17.38	8.95	44.97	860	15	18.9
4543	Rust's Egg Producer	4.12	[5]6.39	6.76	17.93	61.27	3.53	452	25	25.1
4329	Simpson's Poultry Food	7.98	[6]18.61	8.02	13.38	16.93	35.08	870	25	13.0
4544	Triplex Poultry Food	5.96	[7]5.76	4.24	15.44	42.84	25.76	691	25	16.4
4010	Wilbur's Egg and Poultry Food	9.39	3.89	6.38	16.82	11.56	51.96	978	25	11.6
4821	Young's Poultry Food	6.95	[8]5.76	4.15	21.82	15.52	44.80	709	25	16.0

[1] 6.07 per cent. free sulphur.
[2] 2.81 " " " "
[3] 0.56 " " " "
[4] 2.99 " " " "
[5] 1.85 per cent. free sulphur.
[6] 9.51 " " " "
[7] 1.16 " " " "
[8] 1.15 " " " "
[9] Contains also 0.85 per cent. nitrogen as nitrates.

CONDITION POWDERS AND TONICS.

Feed Analysis.

Station Number.	BRAND.	Water.	Ether Extract.	Crude Fiber.	Protein.	Ash.	Nitrogen-free Extract.	Weight of Package.	Price of Package.	Cost per Pound.
		%	%	%	%	%	%	gms.	cts.	cts.
4372	Barker's Vegetable H., C. and Poultry Powder	8.87	[1]8.80	8.82	28.07	11.60	33.84	854	15	19.2
4378	Fairfield's Blood Tonic and Milk Producer	7.88	1.59	2.69	5.56	52.44	29.85	902	25	12.6
4467	" Hog Tonic	6.18	[2]4.08	3.80	9.38	37.60	39.01	828	25	13.7
4468	" Poultry Tonic	8.49	[3]6.00	4.11	28.00	21.89	31.51	771	25	14.7
4048	Weston's Condition Powder	11.66	4.16	2.93	13.81	6.78	60.66	646	25	17.6
4422	Harvell's Condition Powder	6.29	3.80	4.69	[10]17.38	36.67	28.57	454	25	25.0
4181	Hess' Poultry Panacea	8.68	1.42	3.46	[11]9.69	36.77	39.51	583	25	19.5
4325	Rancocas Horse and Cattle Powder	10.20	[4]13.81	7.94	[12]14.88	9.09	43.93	312	25	36.8
4326	" Poultry Powder	13.39	[5]22.43	5.46	11.12	15.48	32.17	412	25	27.5
4324	Myers' Royal Horse and Cattle Spice	10.00	5.57	9.47	18.69	23.75	37.52	872	25	13.0
4323	" Royal Poultry Spice	9.66	4.37	7.99	17.19	13.78	47.06	205	10	22.1
4375	P. and S.'s Our Own Condition Powder	9.30	3.82	9.48	34.38	6.19	36.83	508	25	22.3
4374	Pratt's Animal Regulator	9.44	4.65	2.58	8.44	12.54	62.40	574	25	19.8
4327	Royal Poultry Mixture	0.54	......	......	......	99.46	......	665	25	17.1
4542	Haven's Climax Condition Powder	8.83	[6]6.95	13.00	22.13	7.72	41.37	380	25	29.8
4539	Shuster's Poultry Powder	7.28	[7]8.91	4.53	18.50	25.57	35.21	842	25	13.5
4538	" Condition Powder	8.54	[8]9.45	6.28	22.19	7.43	46.11	873	25	13.0
4541	Sturtevant's Poultry Cure	7.04	3.89	6.38	15.87	28.42	38.90	621	25	21.8
4540	" Medicated Meal	7.71	[9]11.19	8.78	21.94	9.98	40.40	561	25	20.2

[1] 1.83 per cent. free sulphur.
[2] 2.74 " " " "
[3] 1.46 " " " "
[4] 3.66 " " " "
[5] 12.22 " " " "
[6] 1.15 per cent. free sulphur.
[7] 3.30 " " " "
[8] 3.05 " " " "
[9] 1.02 " " " "
[10] Contains also 2.60 per cent. nitrogen as nitrates.
[11] " " 0.47 " " " " "
[12] " " 0.15 " " " " "

CONDIMENTAL STOCK FEEDS.

Mineral Ingredients.

Station Number.	Crude Ash.	Chlorin.	Phosphoric Acid.	Potash.	Soda.	Lime.	Magnesia.	Iron Oxid.	Sulphuric Anhydrid.	Nitric Oxid.	Carbonic Acid.	Sand and Insoluble Matter.
4178	20.54	8.81	1.86	0.80	7.81	1.11	Tr.	Tr.	1.00	1.04	1.77	0.96
4019	21.59	8.98	0.93	1.15	9.52	1.00	Tr.	0.62	1.80	....	*	0.87
4086	14.85	4.51	1.14	1.45	*	0.94	1.50	....	0.84	1.70	*	1.68
4116	4.82	0.52	1.45	1.18	*	0.76	Tr.	....	Tr.	....	*	1.11
4256	18.61	1.67	1.81	1.02	2.10	0.78	Tr.	....	2.58	....	*	1.89
4289	20.60	6.69	8.54	2.91	4.89	0.64	Tr.	....	0.61	....	*	2.02
4522	20.86	9.71	1.75	1.15	*	0.48	0.88	....	Tr.	....	*	0.79
4087	81.77	16.52	1.83	1.12	*	0.69	Tr.	....	0.27	....	*	1.54
4527	7.10	2.04	1.87	1.18	*	0.41	0.49	....	Tr.	....	*	0.48
4828	7.84	0.89	1.72	0.97	*	1.26	0.47	0.49	0.14	0.78	4.77	1.98
4421	15.95	Tr.	1.00	0.51	8.14	0.67	Tr.	....	Tr.	....	11.82	0.48
4330	17.72	8.22	0.40	0.68	*	2.36	2.51	1.28	8.61	....	*	0.92
4545	8.21	8.64	1.25	0.70	*	0.67	Tr.	....	Tr.	....	*	1.47
4011	11.35	4.26	1.67	1.03	*	0.55	Tr.	Tr.	....	....	*	0.91
4276	51.18	Tr.	20.28	0.22	0.36	9.54	0.41	†25.82	Tr.	....	2.98	0.86
4320	10.84	Tr.	1.66	1.91	1.20	0.72	0.28	1.15	0.30	....	....	0.89
4322	14.71	3.89	1.55	2.80	*	1.81	0.65	....	0.11	2.66	*	0.50

* Not determined. †Alumina.

CONDIMENTAL POULTRY FEEDS.

Mineral Ingredients.

Station Number.	Crude Ash.	Chlorin.	Phosphoric Acid.	Potash.	Soda.	Lime.	Magnesia.	Iron Oxid.	Sulphuric Anhydrid.	Nitric Oxid.	Carbonic Acid.	Sand and Insoluble Matter.
4179	23.89	1.91	3.78	0.64	1.68	5.86	Tr.	†5.48	0.76	....	8.57	6.38
4020	19.26	2.64	0.91	0.52	8.27	4.22	1.58	1.59	1.41	....	4.88	2.57
4535	26.88	Tr.	4.87	0.57	*	11.02	0.89	6.47	0.26	....	7.28	1.17
4478	21.08	2.01	1.17	0.83	6.02	0.64	1.00	0.90	3.38	....	8.64	2.70
4449	6.45	Tr.	2.04	1.88	*	0.20	0.56	0.49	0.70	....	*	1.23
4180	26.32	11.62	0.70	1.10	*	0.92	Tr.	Tr.	1.26	1.85	*	1.51
4040	6.16	0.40	1.82	1.09	0.32	0.57	Tr.	2.21	0.26	....	*	1.80
4089	7.64	0.23	2.34	0.77	Tr.	2.94	Tr.	....	Tr.	....	*	0.67
4287	8.95	Tr.	2.97	0.78	0.20	1.92	Tr.	....	0.52	....	*	1.76
4513	61.27	Tr.	17.45	0.22	0.64	20.81	Tr.	†25.82	0.93	....	7.64	1.55
4829	16.98	0.46	1.51	0.47	5.30	1.91	....	1.05	4.41	....	8.75	0.89
4544	42.84	Tr.	12.84	[illegible]	0.59	7.26	Tr.	†17.18	0.60	....	10.20	0.20
4010	11.56	1.87	2.08	1.10	*	1.66	1.43	2.67	....	....	3.06	1.28
4321	15.52	Tr.	5.21	0.97	Tr.	3.64	0.91	Tr.	0.49	....	*	1.41

* Not determined †Alumina.

CONDITION POWDERS AND TONICS.

Mineral Ingredients.

Station Number.	Crude Ash.	Chlorin.	Phosphoric Acid.	Potash.	Soda.	Lime.	Magnesia.	Iron Oxid.	Sulphuric Anhydrid.	Nitric Oxid.	Carbonic Acid.	Sand and Insoluble Matter.
4372	11.60	1.9)	1.32	1.49	*	2.10	0.62	0.75	0.55	....	*	0.54
4373	52.44	22.72	0.86	0.36	23.82	2.16	0.68	....	4.83	....	5.69	0.49
4467	37.60	4.41	0.90	1.04	15.28	1.17	0.82	1.42	5.00	....	11.68	0.29
4468	21.89	8.83	5.48	0.66	*	5.27	0.49	....	0.49	....	*	0.27
4048	6.78	2.61	0.98	0.72	*	0.89	Tr.	....	....	....	*	0.34
4422	36.67	Tr.	0.94	8.87	8.28	2.59	0.38	Tr.	10.30	10.03	*	0.90
4181	36.77	8.12	1.06	1.68	9.55	6.96	Tr.	8.73	1.96	1.81	5.28	1.61
4325	9.69	Tr.	1.95	1.42	*	0.38	1.93	....	1.85	0.53	*	0.43
4326	15.48	Tr.	1.29	2.24	....	0.47	3.69	....	5.00	....	*	0.72
4324	23.75	11.86	0.74	1.24	*	1.04	0.28	....	0.14	....	*	1.27
4323	13.73	5.42	1.01	1.87	*	0.60	0.49	....	0.16	....	*	0.86
4375	6.19	Tr.	1.52	1.11	*	0.80	0.58	0.87	Tr.	....	*	0.60
4374	12.54	6.32	0.52	0.43	*	0.66	0.18	....	....	....	*	0.48
4327	99.46	Tr.	0.17	0.05	*	37.26	9.11	10.01	Tr.	....	19.16	1.98
4542	7.72	Tr.	1.39	1.02	*	0.86	0.77	....	0.66	....	*	1.16
4539	25.57	Tr.	1.41	0.98	1.05	9.79	Tr.	....	1.26	....	13.59	1.65
4538	7.48	Tr.	1.50	1.39	0.20	0.77	Tr.	....	0.76	....	*	0.14
4541	28.42	1.99	6.86	1.07	2.05	9.84	Tr.	†11.76	1.88	....	7.93	1.85
4540	9.98	3.00	1.68	1.38	*	0.84	Tr.	....	0.84	....	*	0.79

* Not determined. † Mostly alumina.

The following materials were found to be the base of the feeds the number of times indicated, either alone or in combination:

Wheat feed or bran......	37	Oats	2
Corn meal..............	16	Millet seed.................	2
Linseed meal............	16	Gluten feed.................	1
Dried blood.............	4	Meat meal..................	1
Ground bone............	4	Magnesian limestone........	1
Bean meal..............	3	Sodium chlorid.............	1
Cottonseed meal.........	2		

In addition to these bases, the following materials were used in various combinations: Sodium chlorid (28), Epsom salts (26), sulphur (21), lime (18), charcoal (15); carbonate of lime, as oyster shells (13); oxid of iron (13), Glauber's salt (12), fenugreek (12), pepper (12), saltpetre (8), linseed meal (6), gentian (7), silicate of alumina (5), magnesian limestone (4), carbonate of soda (4), copperas (3), cottonseed meal (3), corn meal (3), turmeric (3), rosin

(2), ginger (2), fennel (2), mustard hulls (2), ground bone (2), dried blood (1), mica (1), aniseed (1), senna (1), and asafœtida (1).

Wheat feed, corn meal and linseed meal, either alone or in combination, form the base of all but three of these mixtures, wheat feed being most commonly used. The examination of the mineral ingredients present showed that large quantities of minerals had been added in nearly every case, the total ash ranging from 4.82 to 99.46 per cent. Of the fifty samples, thirty-five contained over 10 per cent. ash, twenty-two over 20 per cent., and five over 50 per cent., while one sample was practically all mineral matter. Common salt was the most commonly added mineral, ranging from traces to 37.42 per cent., ten samples showing over 10 per cent. Free sulphur was found in twenty-one samples, ranging from 0.56 to 12.22 per cent. Epsom salts, lime, charcoal, carbonate of lime (usually as oyster shells), and Glauber's salt, were also found quite generally. In thirteen samples oxid of iron (Venetian red) was found; this material has no medicinal value and was doubtless used to conceal by its brick-red color the use of other ingredients; sulphate of iron (copperas), which possesses value as a tonic, was found in but three of the samples. Saltpetre was found in eight samples, ranging from 1.08 to 18.73 per cent. Magnesian limestone was found in five samples, in one case nearly the whole sample being that material. No injurious or poisonous matter was found in any of the samples; nor was there any evidence of the use of sand as make-weight save in one sample, No. 4179, where 6.38 per cent. was insoluble in hydrochloric acid; the insoluble matter in the other samples was generally less than 2 per cent., and in more than half of them less than 1 per cent. In four samples, however, alumina was found in large quantities, ranging from 11.76 to 25.32 per cent. As the insoluble matter was low in all of these samples, it would seem that a hydrated silicate of alumina was employed. The use of this material could have been only for the purpose of make-weight, as it possesses no value as a medicine.

Of the vegetable drugs, fenugreek and pepper were most extensively used, probably for their aromatic and stimulating properties; gentian, ginger, turmeric, fennel, aniseed, senna and asafœtida were also found in a few cases.

Conclusions.

A consideration of the above data, together with the feeding experiments conducted at various Experiment Stations, leads to the following general conclusions:

1. A loss of appetite, or a run-down condition, induced by overwork or insufficient feed, may often be remedied by the use of a stimulating or tonic food, the ingredients for making which the feeder should always keep at hand. In the majority of cases simply a change of food will bring about the desired effect, but when this is ineffective a liberal use of common salt in a ration will generally prove beneficial. In the case of horses the use of linseed meal will be frequently found of marked benefit as a laxative.

2. The brand name of a condimental feed is no certain indication that it is effective for the animal specified.

3. The claims of the manufacturers of condimental feeds, when not preposterous, are exaggerated and misleading. No one feed, however skillfully compounded, can serve as a remedy for all the ailments of all classes of live stock.

4. Instead of being prepared according to scientific formulas, as claimed, many of the condimental feeds are heterogeneous mixtures with little regard to the requirements of the animal, and in certain cases the drugs used have a counteracting effect on each other.

5. Even where effective drugs have been used, the amount of the mixture to be given to the animal, according to the instructions of the manufacturer, is generally so small that no possible benefit can be expected from its use.

6. Assuming that the condimental feeds are scientifically prepared mixtures of useful and effective ingredients, and their use as directed would confer upon the animal the benefits claimed, their excessive cost would prohibit their use by the careful and economical feeder. Such ingredients, which they contain and which might be of benefit, any feeder can obtain and mix for himself at from one-tenth to one twentieth the cost of the prepared foods. He would have the added advantage of knowing just what drugs he was administering to his animals and could give them such quantities of the needed medicines as veterinary experience has shown to be necessary.

INVESTIGATIONS RELATIVE TO THE USE OF NITROGENOUS MATERIALS.*

BY EDWARD B. VOORHEES AND JACOB G. LIPMAN.

The cumulative value of vegetation experiments conducted through a series of years is due largely to the elimination of seasonal and other inequalities which frequently interfere with the proper interpretation of the experimental data. The average of a large number of crops grown under given conditions represents more truly the relation of soil to crop and of fertilizer to soil than may be represented by the yield of a single season. Aside, however, from the peculiarities of rainfall or temperature, that change from season to season and tend to offset one another in the course of years, there are differences of a more permanent character. Scarcely perceptible at first, they become more and more pronounced in long-continued experiments until the comparative merits of different systems of rotation, or of differing systems of fertilization become clearly established. The experiments reported here were planned so as to permit the recognition of both the temporary and the permanent differences introduced in the one case by the seasonal peculiarities, in the other by the more deep-seated modifications in the chemical, physical and biological properties of the various soils. The corn crop of 1898 was followed by oats in 1899, by another crop of oats in 1900, by winter wheat in 1901 and by timothy in 1902. The latter was the last crop of the five-year rotation and was followed in 1903 by another corn crop, which marked the beginning of the second rotation. This, in turn, was followed successively by two oat crops, a critical comparison of whose yields is made in the following pages. The two oat crops of the first rotation added to those of the second rotation furnish an abundance of experimental material, which may be used to demonstrate how a one-sided system of fertilization affects the crop-producing power of the soil. It becomes clear here what the comparative value of nitrate, of ammonia, or organic nitrogen may be, and to what extent they may be used as a source of nitrogen when applied alone or together with animal manures.

* See N. J. Sta. Reports, 1899, 1900, 1901, 1902, 1903 and 1904.

The Oat Crop of 1904.

The Manures Used.

As in preceding reports, the composition of the manures used in the experiment is reported, and for the sake of comparison the average composition of eight other samples is also given, as may be seen from the analyses reported below.

THE COMPOSITION OF THE SOLID AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, FRESH.

The fresh manures collected in the customary manner had the following composition:

Fresh Manure, Solid.

	1904. Per cent.	Average of eight other samples. Per cent.
Water	84.220	85.023
Ash	2.051	2.241
Organic matter	13.729	12.736
Nitrogen (total)	0.457	0.340
" soluble in H_2O	0.086	0.062
" as nitrate	0.000	0.005
" as ammonia	0.023	0.022
" as soluble organic	0.063	0.035
" as insoluble organic	0.371	0.278
Phosphoric acid	0.201	0.336
Potash	0.141	0.196

The above figures show that the sample of 1904 was considerably richer in total nitrogen than the average of the other samples, but poorer in phosphoric acid and potash. It also had a higher content of soluble nitrogenous substances, and likewise a higher content of organic matter. The content of ash was lower here than in the average of the other samples.

Fresh Manure, Solid and Liquid.

	1904. Per cent.	Average of eight other samples. Per cent.
Water	88.379	87.405
Ash	2.035	2.046
Organic matter	9.586	10.549
Nitrogen (total)	0.476	0.444
" soluble in H_2O	0.248	0.230
" as nitrate	0.000	0.005
" as ammonia	0.043	0.109
" as soluble organic	0.205	0.116
" as insoluble organic	0.228	0.214
Phosphoric acid	0.130	0.265
Potash	0.455	0.422

The sample of 1904 did not differ much in composition from the average for the other samples, with the exception of phosphoric acid, which was much lower in 1905. The ash, total and water-soluble nitrogen, as well as the potash, show comparatively slight differences. The water content in the sample of 1904 was by about 1 per cent. higher than in the average of the eight other samples, while the content of organic matter was lower by slightly less than 1 per cent.

THE COMPOSITION OF THE SOLID AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, LEACHED.

The fresh manures were exposed to the leaching action of rain in the customary manner from February 15th until April 15th, 1904. The composition of the manures, both before and after leaching, is given below. During that time the 100 pounds of manure were reduced to seventy-nine pounds in the case of the solid manure, and to sixty-two pounds in the case of the solid and liquid manure. The losses sustained in leaching may be computed from the analyses of the materials, both before and after leaching, when taken in connection with the initial and final weights of the manures in question. It should also be added here that on account of an error in the method of computation the previous estimates of the losses incurred were unduly exaggerated, though fortunately in the right direction for practical purposes.

Solid, Fresh, Previous to and After Leaching.

	Fresh. Per cent.	Leached. Per cent.
Water	83.073	82.266
Ash	2.268	1.946
Organic matter	14.659	15.788
Nitrogen (total)	0.361	0.366
" soluble in water	0.050	0.085
" as nitrate	0.000	0.000
" as ammonia	0.028	0.048
" as soluble organic	0.022	0.037
" as insoluble organic	0.311	0.281
Phosphoric acid	0.320	0.323
Potash	0.203	0.224

Solid and Liquid, Fresh, Previous to and After Leaching.

	Fresh. Per cent.	Leached. Per cent.
Water	87.193	81.135
Ash	1.661	2.141
Organic matter	11.146	16.724
Nitrogen (total)	0.430	0.489
" water soluble	0.236	0.184
" as nitrate	0.000	0.000
" as ammonia	0.162	0.144
" as soluble organic	0.074	0.040
" as insoluble organic	0.194	0.305
Phosphoric acid	0.241	0.391
Potash	0.456	0.355

The corresponding analyses for other years have been fully discussed in previous reports, making it unnecessary to discuss again the present data. It may be pointed out here, however, that the exposure involves not merely a loss of soluble salts but also of moisture, since the leached samples are always drier than the corresponding fresh samples. The reduced moisture content as well as the elimination of the bulk of the soluble salts influence materially the bacterial changes in the manure, for with retarded bacterial development the losses from fermentation must of necessity be smaller than those in large piles of manure. Retarded fermentation in its turn involves a retarded solution of the insoluble constituents, and hence a diminished loss from the leaching action of rain. It appears, therefore, that under the conditions of the experiments the losses involved are not exaggerated, notwithstanding the comparatively small amounts of manure under investigation.

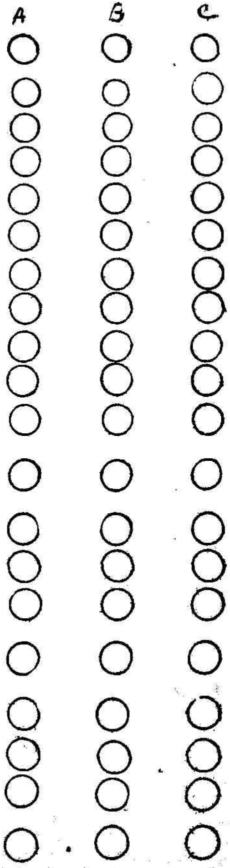
The Experiment Plant.

The accompanying diagram shows the arrangement of the several cylinders, and is inserted here to add clearness to the experimental data presented below.

Diagram of Experiment.

Series.

1. Check ....
2. Minerals ....
3. Manure, solid, fresh ....
4. Manure, solid and liquid, fresh .....
5. Manure, solid, leached ....
6. Manure, solid and liquid, leached ....
7. Nitrate of soda, 5 gms. ....
8. Nitrate of soda, 10 gms. ....
9. Manure, solid, fresh; nitrate, 5 gms..
10. Manure, solid, fresh; nitrate, 10 gms.
11. Manure, solid and liquid, fresh; nitrate, 5 gms. ....
12. Manure, solid and liquid, fresh; nitrate, 10 gms. ....
13. Manure, solid, leached; nitrate, 5 gms. ....
14. Manure, solid, leached; nitrate, 10 gms. ....
15. Manure, solid and liquid, leached; nitrate, 5 gms. ....
16. Manure, solid and liquid, leached; nitrate, 10 gms. ....
17. Sulphate of ammonia ....
18. Dried blood ....
19. Manure, solid, leached; sulphate of ammonia ....
20. Manure, solid, leached; dried blood ..



Application of Manures and Fertilizers.

After the removal of the corn in 1903 the cylinder soils were kept bare throughout the winter, and carefully spaded in the spring of 1904. The manures and fertilizers were applied in the customary manner on April 23d, the former being distributed in an even layer about four inches below the surface, the latter carefully mixed with the surface soil.

Amounts Applied.

It was the aim to have the different kinds of manure applied uniform in amount, and slightly greater than that used in ordinary farm practice, and corresponding with that frequently used in market gardening. The application was in no case so excessive as to render the conditions different from those observed in good farm practice, being at the rate of sixteen tons per acre.

In the case of the concentrated nitrogenous fertilizers the nitrate was applied at the rate of five grams per cylinder in 7, 9, 11, 13 and 15, respectively; and at the rate of ten grams per cylinder in series 8, 10, 12, 14 and 16. The ammonium sulphate was applied at the rate of eight grams in series 17 and 19, and the dried blood at the rate of thirteen grams in series 18 and 20. All of these materials were applied in full amount on the date given. The acid phosphate and muriate were applied at the same time in the usual amounts, namely, twenty grams and ten grams, respectively, in each cylinder.

The quantities of manure applied were: of solid, fresh, 1 lb. 15 oz. = 4.02 grams nitrogen; of solid and liquid, fresh, 1 lb. 14 oz. = 4.05 grams nitrogen; of solid, leached, 2 lbs. 8 oz. = 4.15 grams nitrogen; of solid and liquid, leached, 2 lbs. 8 oz. = 5.55 grams nitrogen. Water was applied from the hose on the different cylinders whenever the rainfall seemed insufficient, the amounts thus applied being uniform in the several cylinders.

The Crops Grown.

Oats were grown in the cylinder soils in 1904, and were followed by corn as a residual crop. Each soil received about one hundred seeds that showed later a fairly good germination. As was noted on previous occasions, the germination in series 1 was retarded, an indi-

cation that the less favorable chemical and physical properties in the soils of this series rendered rapid germination difficult.

In calculating the yield, the average of the three plots in any one series is usually taken, and, by subtracting the average yield on the check plots, the yield due to the particular manure or fertilizer is obtained. Thus, by subtracting the average yield on series 2 from that on series 8, the yield due to the ten grams of nitrate applied on the latter series is obtained. It is necessary, of course, to assume here that the amount of nitrogen obtained from the soil itself by the crops on series 8 is equal to the amount of nitrogen obtained from the soil by the crops on series 2, where no nitrogen is applied. As a matter of fact, the average amount of nitrogen withdrawn from the soil itself on series 8 is never equal to, but always greater than, the average amount of nitrogen withdrawn from the soil on series 2. The reason for this is evident, if we consider that the soil nitrogen becomes soluble very gradually, and the thoroughness with which this soluble nitrogen is utilized by the growing crop depends on the root development of the individual plants. It is quite apparent that the plants on series 2 will grow but slowly, since the amount of nitrogen placed at their disposal is very meager. In consequence of this limited growth the root development of the plants will be rather limited, and therefore not capable of appropriating all, or most of, the nitrogen, rendered soluble in the course of the season, and particularly in the early part of it. On the other hand, the nitrate nitrogen offered to the plants on series 8 will make possible a good root development and a more thorough utilization of the nitrogen derived from the soil itself. Moreover, the sodium nitrate will exert a solvent action on the soil humus over and above that exerted by the substances applied on series 2. Thus it will be seen that the average amount of nitrogen credited to the nitrate on series 8 will partly consist of the nitrogen derived from the soil in excess of the average amount derived from the soil of series 2. Since the soil nitrogen becomes soluble but slowly, the amount obtained by the growing crop will be directly proportional to the length of the growing season, a circumstance that should not be left out of consideration in the study of the yields on the different series and in different seasons.

The oats were harvested on June 28th, and after thorough air-drying were taken to the laboratory for analysis.

Results of the Oat Experiment, 1904.

The accompanying table shows the actual dry matter in the crop from each series, the percentage of nitrogen found, the gain in nitrogen, due to the materials added, and the percentage of the applied nitrogen recovered. In all cases the net gains in the different series are derived by subtracting the average gain obtained on series 2, on which minerals only were applied, from the average gain obtained on that particular series.

The Oat Crop, 1904.

		Nitrogen applied.	Air-dry matter in crop.	Nitrogen in air-dry matter.	Nitrogen in crop	Increase over check plots.	Per cent. of nitrogen recovered.	Average.
		gms.	gms.	%	gms.	gms.	%	%
1	A		36	1.472	0.530			
	B		39	1.376	0.537			
	C		34	1.363	0.468			
2	A		67	1.198	0.803			
	B		75	1.073	0.805	(0.805)		
	C		72	1.120	0.806			
3	A	4.02	133	1.142	1.519	0.714	17.8	
	B		122	1.168	1.425	0.620	15.4	15.2
	C		116	1.120	1.299	0.494	12.3	
4	A	4.05	149	1.302	1.940	1.135	28.0	
	B		169	1.225	2.070	1.265	31.2	29.6
	C		156	1.285	2.005	1.200	29.6	
5	A	4.15	124	1.229	1.524	0.719	17.3	
	B		125	1.046	1.308	0.503	12.1	13.4
	C		107	1.175	1.257	0.452	10.9	
6	A	5.55	149	1.317	1.962	1.157	20.8	
	B		151	1.192	1.800	0.995	17.9	20.6
	C		151	1.377	2.079	1.274	23.0	
7	A	0.78	102	1.262	1.287	0.482	61.8	
	B		111	1.140	1.265	0.460	59.0	58.0
	C		101	1.207	1.219	0.414	53.1	
8	A	1.55	130	1.329	1.728	0.923	59.5	
	B		108	1.286	1.389	0.584	*37.7	56.1
	C		122	1.329	1.621	0.816	52.6	
9	A	4.80	141	1.306	1.841	1.036	21.6	
	B		145	1.381	2.002	1.197	24.9	22.6
	C		134	1.361	1.824	1.019	21.2	
10	A	5.57	156	1.420	2.215	1.410	25.3	
	B		155	1.479	2.292	1.487	26.7	25.5
	C		156	1.392	2.172	1.367	24.5	
11	A	4.83	166	1.424	2.364	1.559	32.3	
	B		163	1.412	2.302	1.497	31.0	32.7
	C		158	1.578	2.493	1.688	34.9	
12	A	5.60	157	1.680	2.637	1.832	32.7	
	B		160	1.570	2.412	1.607	28.7	31.4
	C		164	1.613	2.645	1.840	32.9	
13	A	4.93	131	1.365	1.788	0.983	19.9	
	B		132	1.392	1.837	1.032	20.9	19.6
	C		124	1.365	1.693	0.888	18.0	
14	A	5.70	145	1.436	2.082	1.277	22.4	
	B		155	1.460	2.263	1.458	25.6	23.4
	C		141	1.471	2.074	1.269	22.3	
15	A	6.33	161	1.400	2.254	1.449	22.9	
	B		164	1.262	2.070	1.265	20.0	21.3
	C		158	1.358	2.138	1.333	21.1	
16	A	7.10	174	1.471	2.560	1.755	24.7	
	B		168	1.482	2.334	1.529	21.5	21.8
	C		149	1.451	2.162	1.357	19.1	
17	A	1.62	111	1.262	1.401	0.596	36.8	
	B		119	1.231	1.465	0.660	40.7	38.8
	C		101	1.270	1.283	0.478	*29.5	
18	A	1.55	95	1.160	1.102	0.297	*19.2	
	B		95	1.274	1.210	0.405	26.1	27.8
	C		101	1.250	1.263	0.458	29.5	
19	A	5.77	140	1.408	1.971	1.166	20.1	
	B		148	1.361	1.946	1.141	19.8	19.5
	C		129	1.451	1.872	1.067	18.5	
20	A	5.70	121	1.460	1.766	0.961	16.9	
	B		137	1.302	1.784	0.979	17.2	18.7
	C		139	1.487	2.067	1.262	22.1	

* Not included in the average.

Average Composition of the Crop.

Series.	Dry Matter. gms.	Nitrogen. Per cent.	Nitrogen. gms.
1	36.3	1.405	.510
2	71.3	1.129	.805
3	123.7	1.143	1.414
4	158.0	1.269	2.005
5	118.7	1.150	1.365
6	150.3	1.295	1.947
7	104.7	1.201	1.257
8	120.0	1.316	1.579
9	140.0	1.349	1.889
10	155.7	1.429	2.226
11	162.3	1.470	2.386
12	160.3	1.600	2.565
13	129.0	1.374	1.773
14	147.0	1.456	2.140
15	161.0	1.338	2.154
16	162.0	1.454	2.352
17	110.3	1.257	1.387
18	97.0	1.229	1.192
19	137.3	1.406	1.930
20	132.3	1.415	1.872

The above table shows the average content of dry matter and of nitrogen as well as the average *proportion* of nitrogen in the crop from each series. It will be noted that the yield of dry matter in series 2 was almost double that in series 1. On the other hand, the nitrogen content of the crop in series 2 is by no means proportionately as great. The difference is due to the higher proportionate content of nitrogen in the crop from series 1. The accumulation of nitrogen in the latter crop is due, as was pointed out in previous reports, to the lack of available phosphoric acid in the soils of series 1. It will also be observed that the percentage of nitrogen in the crop from series 2 is lower than that in the crop from any other series. Evidently the nitrogen serving as the minimum factor here, and placed at the disposal of the crop in much smaller amounts than was true of the other soils, was utilized to the fullest extent. A comparison of series 3 and 4 will show that the solid portion yielded less dry matter and less nitrogen than the corresponding solid and liquid portion. Moreover, the dry matter from series 4 contained also a higher percentage of nitrogen. Similarly, in series 5 and 6, where the solid, leached, and the solid and liquid, leached, respectively, was applied, the yield from the latter contained more dry matter and a greater absolute and pro-

portionate amount of nitrogen. In series 7, with five grams of sodium nitrate, the yield of dry matter and of nitrogen was smaller than in series 8, where ten grams of nitrate were applied. The proportionate content of nitrogen was also higher in the latter series. The double quantities of nitrate show a similar and consistent increase in all of the other series, where it was used together with the fresh or leached manures. Thus, in the even series, 10, 12, 14 and 16, the yield of dry matter and of nitrogen is greater in all but one case than in the corresponding odd series, 9, 11, 13 and 15. The single exception, the smaller yield of dry matter in 12, as compared with series 11, is more than offset by the higher percentage of nitrogen in the crop from series 12 and the greater absolute yield of nitrogen. Also in combination the solid and liquid, fresh, proved superior as a source of nitrogen to the solid, fresh. Similarly, the solid and liquid, leached, proved a better source of nitrogen than the solid, leached, although it should be remarked here that the latter was applied in smaller quantities than the former. A comparison of the yields from series 8, 17 and 18 will show that the equivalent quantities of nitrogen in nitrate, ammonium sulphate and dried blood led to very unequal results. The average yield from series 8 was 1.579 grams of nitrogen; that from series 17, 1.387 grams of nitrogen, and from series 18, 1.192 grams of nitrogen. The combination of ammonium sulphate and leached manure gave a higher crop return than the corresponding combination of manure and dried blood. It will also be noted that the dried blood yielded less dry matter and less nitrogen than the five grams of nitrate in series 7, containing only half the amount of nitrogen. The ammonium sulphate, on the other hand, while it gave a higher yield of both dry matter and of nitrogen than the nitrate in series 7, fell short of the yield from the equivalent quantity of nitrate nitrogen in series 8.

Average Increase Over the Check Plot, and the Average Per Cent. of the Nitrogen Recovered.

Series.	Increase in Yield of Nitrogen. gms.	Nitrogen Recovered. Per cent.
1	....	....
2	....	....
3	.609	15.2
4	1.200	29.6
5	.558	13.4
6	1.142	20.6
7	.452	58.0
8	.774	56.1
9	1.084	22.6
10	1.421	25.5
11	1.581	32.7
12	1.760	31.4
13	.968	19.6
14	1.335	23.4
15	1.349	21.3
16	1.547	21.8
17	.578	38.8
18	.387	27.8
19	1.125	19.5
20	1.067	18.7

In this, as in the preceding table, the solid and liquid, fresh, is shown to have yielded more nitrogen to the crop than was true of the solid, fresh. Similarly, the solid and liquid, leached, yielded more nitrogen to the crop than did the solid, leached. Similar relations hold true in the soils where these manures were used in combination with nitrate. The recovery from the different materials used varies from 13.4 per cent. in the solid, leached, to 58 per cent. in the nitrate. The recovery from the solid, fresh, was only about half that from the solid and liquid, fresh, but was somewhat greater than that from the solid, leached. The recovery from the solid and liquid, leached, was 20.6 per cent., as compared with the 29.6 per cent., recovered from the solid and liquid, fresh. The single quantity of nitrate showed a higher recovery than the double quantity. The recovery from the ammonium sulphate was 38.8 per cent. and from the dried blood 27.8 per cent., as compared with 56.1 per cent. recovered from the corresponding amount of nitrate nitrogen.

The Corn Crop, 1904.

After the oats were harvested the soil was thoroughly prepared, and corn was planted in each of the cylinders without further addition of plant-food. It was the intention in planting this crop to exhaust the more readily available nitrogen in the different cylinders, as well as to study the effect upon plant growth of the residual nitrogen contained in the various manurial substances applied to the oats. The germination was good, though retarded in series 1, and the growth of the plants was not affected by any untoward circumstances.

Corn, 1904.

	Residual nitrogen.	Air-dry matter in crop.	Nitrogen in air-dry matter.	Nitrogen in crop.	Increase over check plots.	Per cent of nitrogen recovered.	Average.
	gms.	gms.	%	gms.	gms.	%	%
1 A	....	26	1.341	0.349	....	....	....
1 B	....	32	1.321	0.428	....	....	....
1 C	....	38	1.231	0.468	....	....	....
2 A	....	47	0.931	0.438	....	....	....
2 B	....	48	0.895	0.480	(0.444)	....	....
2 C	....	47	0.990	0.465	....	....	....
3 A	3.31	104	0.872	0.907	0.463	14.0	....
3 B	3.40	94	0.828	0.778	0.334	9.8	11.9
3 C	3.53	93	0.927	0.862	0.418	11.8	....
4 A	2.91	95	0.805	0.765	0.321	11.0	....
4 B	2.73	93	0.797	0.741	0.297	10.7	10.2
4 C	2.85	82	0.848	0.695	0.251	8.8	....
5 A	3.43	106	0.797	0.845	0.401	11.7	....
5 B	3.65	82	0.903	0.740	0.296	8.2	8.7
5 C	3.70	76	0.887	0.674	0.230	6.2	....
6 A	4.39	104	0.785	0.816	0.372	8.5	....
6 B	4.55	102	0.824	0.840	0.396	8.7	8.6
6 C	4.26	91	0.896	0.815	0.371	8.7	....
7 A	0.30	44	0.966	0.425	....	....	....
7 B	0.32	45	0.959	0.432	....	....	4.0
7 C	0.37	46	0.998	0.459	0.015	4.0	....
8 A	0.63	44	0.911	0.401	....	....	....
8 B	0.97	62	0.907	0.562	0.118	12.2	6.8
8 C	0.73	47	0.966	0.454	0.010	1.4	....
9 A	3.76	103	0.813	0.837	0.393	10.5	....
9 B	3.60	101	0.809	0.817	0.373	10.4	10.4
9 C	3.78	102	0.888	0.906	0.462	12.2	....
10 A	4.16	97	0.907	0.880	0.436	10.5	....
10 B	4.08	123	0.852	1.048	0.604	14.8	12.3
10 C	4.20	102	0.911	0.929	0.485	11.5	....
11 A	3.27	99	0.802	0.794	0.350	10.7	....
11 B	3.33	101	0.860	0.869	0.425	12.8	13.4
11 C	3.14	92	1.049	0.965	0.521	16.6	....
12 A	3.77	104	0.821	0.854	0.410	10.9	....
12 B	3.99	94	0.798	0.750	0.306	7.7	11.1
12 C	3.76	109	0.919	1.002	0.558	14.8	....
13 A	3.95	122	0.798	0.974	0.530	13.4	....
13 B	3.90	81	0.895	0.725	0.281	7.2	9.8
13 C	4.04	93	0.856	0.796	0.352	8.7	....
14 A	4.42	100	0.864	0.864	0.420	9.5	....
14 B	4.24	88	0.864	0.760	0.316	7.5	7.9
14 C	4.48	92	0.809	0.744	0.300	6.8	....
15 A	4.88	109	0.829	0.904	0.460	9.4	....
15 B	5.06	102	0.825	0.842	0.398	7.9	9.4
15 C	5.00	115	0.861	0.990	0.546	10.9	....
16 A	5.34	107	0.806	0.862	0.418	7.8	....
16 B	5.57	109	0.829	0.904	0.460	8.3	7.2
16 C	5.74	96	0.795	0.763	0.319	5.6	....
17 A	1.02	42	0.857	0.360	....	....	....
17 B	0.96	48	0.846	0.406	....	....	1.4
17 C	1.14	50	0.920	0.460	0.016	1.4	....
18 A	1.25	57	0.865	0.493	0.049	3.9	....
18 B	1.14	65	0.841	0.547	0.103	9.0	6.8
18 C	1.09	58	0.905	0.525	0.081	7.4	....
19 A	4.60	68	0.936	0.636	0.192	4.2	....
19 B	4.63	87	0.908	0.790	0.346	7.5	6.1
19 C	4.70	86	0.885	0.761	0.317	6.7	....
20 A	4.74	124	0.798	0.990	0.546	11.5	....
20 B	4.72	104	0.826	0.859	0.415	8.8	10.4
20 C	4.44	106	0.877	0.930	0.486	10.9	....

The above data show, as a rule, a fairly good agreement in the parallel plots of each series. They also show that the soluble nitrate nitrogen was quite thoroughly utilized by the first crop, leaving no more available nitrogen than was left in the check series 2. Also the ammonium sulphate nitrogen was utilized thoroughly, and the dried blood nitrogen only slightly less so. On the other hand, the first crop failed to withdraw from the soil a very large proportion of the nitrogen applied in the fresh and leached manures. The residues continued to decay slowly and their nitrogen was rendered available very gradually, thus enabling the succeeding corn crop to gather a considerable amount of this available nitrogen. A study of the recoveries from the residual nitrogen shows that the residues in the solid, fresh, of series 3 yielded more nitrogen than did the residues in the solid and liquid, fresh, in series 4. Similarly, the residues in series 5 showed a proportionately larger recovery than did the residues in series 6. The recoveries from the residual nitrogen in series 9, 10, 11, 12, 13, 14, 15 and 16 were also quite considerable, particularly in series 10 and 11, which showed recoveries of 12.30 per cent. and of 13.40 per cent., respectively. It will be noted, also, that the residues in series 20, where solid, leached, and dried blood were used in combination, yielded more nitrogen to the corn crop than did the residues in series 19, where the solid, leached, was used in combination with ammonium sulphate.

Average Composition of the Crop.

Series.	Dry Matter. gms.	Nitrogen. Per cent.	Nitrogen. gms.
1	32.0	1.290	.413
2	47.3	.939	.444
3	97.0	.875	.849
4	90.0	.816	.734
5	88.0	.856	.753
6	99.0	.832	.824
7	45.0	.975	.439
8	51.0	.925	.472
9	102.0	.836	.853
10	107.3	.887	.952
11	97.3	.900	.876
12	102.3	.849	.869
13	98.7	.843	.832
14	93.3	.846	.789
15	108.7	.839	.912
16	104.0	.811	.843
17	46.7	.876	.409
18	60.0	.870	.522
19	80.3	.908	.729
20	111.3	.832	.926

As in the preceding crop, the average yield of corn in series 2 was much greater than the corresponding yield in series 1. At the same time the crop in the latter was proportionately richer in nitrogen, so that the yield of nitrogen in the two series showed but a comparatively small difference. The yield of dry matter and of nitrogen in series 3 was greater than the corresponding yield in series 4, thus reversing the relations noted in the oat crop. Evidently the residues from the solid and liquid manures, fresh, could not offer as much available nitrogen to the corn crop as did the residues from the solid manure, fresh. The same relations do not hold good in series 5 and 6, where the corresponding leached manures were employed, largely because the initial quantity of nitrogen applied in series 6, viz., 5.55 grams, was considerably greater than that applied in series 5, viz., 4.15 grams. The average yield of dry matter in series 7 was 45.0 grams as against a corresponding yield of 51.0 grams in series 8. On the other hand, the proportionate amount of nitrogen was higher in the crop from series 7, making the difference in the total yield of nitrogen rather slight. It was already noted elsewhere that the total yield of nitrogen in series 7 was slightly less than that in the check series 2, and that the corresponding yield in series 8 was not much greater. The yield of nitrogen in series 17, where ammonium sulphate was applied, was even smaller than that in series 7, where only half of the equivalent quantity of nitrogen was applied as nitrate. In this case, however, the lower yield in series 17 should not be attributed to the more thorough exhaustion of the available soil nitrogen, but to conditions depressing the activity of the decay bacteria in these soils. The continuous application of ammonium sulphate for seven successive seasons increased the acidity of the soil, unfavorably affecting thereby its bacterial flora. This depressing action is apparent, also, in series 19, where the ammonium sulphate was used in combination with solid manure, leached. The average yield in series 9, where five grams of nitrate were applied, together with the solid, fresh, consisted of 102.0 grams of dry matter, containing .853 grams of nitrogen, as compared with 97.3 grams of dry matter, containing .876 grams of nitrogen, in series 11, where the same quantity of nitrate was used in combination with solid and liquid, fresh. In series 10, where ten grams of nitrate were used in combination with the solid, fresh, there was a yield of 107.3 grams of dry matter and of .952 grams of nitrogen, as compared with 102.3 grams of dry matter and only .869 grams of nitrogen in series 12, where the same quantity of

nitrate was used in combination with the solid and liquid, fresh. It appears thus that on the whole the residues in the solid, fresh, yielded more nitrogen to the corn crop than did the residues in the solid and liquid, fresh, whether used alone or in combination with nitrate. In the leached manures, when used in combination with nitrate, the solid and liquid portion yielded more nitrogen to the corn crop than did the solid portion, largely because of the greater quantity of nitrogen applied in the solid and liquid portion.

The Average Increase Over Check Plot, and the Average Per Cent. of Nitrogen Recovered.

Series.	Average Increase. gms.	Nitrogen Recovered. Per cent.
1	....	....
2	....	....
3	.405	11.9
4	.290	10.2
5	.309	8.7
6	.380	8.6
7	....	....
8	....	....
9	.409	10.4
10	.508	12.3
11	.432	13.4
12	.425	11.1
13	.388	9.8
14	.345	7.9
15	.468	9.4
16	.399	7.2
17	....	....
18	.078	6.8
19	.285	6.1
20	.482	10.4

The average increase in the yield of nitrogen was .405 grams in series 3, as against .290 grams in series 4. The average increase in series 9 was .409 grams, while the average increase in series 11 was .432 grams. Remembering that the soils in series 9 received an application of solid manure, fresh, like that in series 3, and in addition also 5 grams of nitrate, and that the soils in series 11 received an application of solid and liquid, fresh, and in addition also five grams of nitrate, it becomes clear that the residual effect of the combined manure and nitrate in series 9 was practically the same as that

of the manure alone in series 3. On the other hand, the residual effect of the combination of manure and nitrate in series 11 exceeded that of the manure alone in series 4. In series 10, where ten grams of nitrate were used together with the solid, fresh, the residual effect exceeded that in series 9, whereas the corresponding application of nitrate in series 12 showed no greater effect than the smaller application of nitrate in 11. Comparing similarly series 13 and 14, we note that the residual effect in the latter series, notwithstanding the double application of nitrate, or because of it, was slighter than the residual effect in series 13. The same is also true of series 15 and 16, respectively. The total increase in series 3, 9 and 10, where the solid, fresh, was used alone or in combination, was 1.422 grams as against the total increase of 1.147 grams in series 4, 11 and 12, where the solid and liquid, fresh, was used alone or in combination. The corresponding relations in the leached manures are not seen as easily at a glance, because of the greater quantity of nitrogen applied in the solid and liquid portion, leached; a fact already noted above.

Both Crops.

		Dry matter in crop.	Nitrogen in crop.	Increase over check plots.	Per cent. of nitrogen recovered.	Average.
		gms.	gms.	gms.	%	%
1	A	62	0.879			
	B	71	0.960			
	C	72	0.931			
2	A	114	1.241			
	B	128	1.285	(1.249)		
	C	119	1.271			
3	A	237	2.426	1.177	29.8	
	B	216	2.203	0.954	28.7	25.2
	C	209	2.161	0.912	22.7	
4	A	244	2.705	1.456	36.0	
	B	262	2.811	1.562	38.6	36.8
	C	238	2.700	1.451	35.8	
5	A	230	2.369	1.120	27.0	
	B	207	2.048	0.799	19.3	20.9
	C	183	1.931	0.682	16.4	
6	A	253	2.778	1.529	27.5	
	B	258	2.640	1.391	25.1	27.4
	C	242	2.894	1.645	29.6	
7	A	146	1.712	0.463	59.4	
	B	156	1.697	0.448	57.4	57.3
	C	147	1.678	0.429	55.0	
8	A	174	2.129	0.880	56.8	
	B	170	1.951	0.702	45.3	51.8
	C	169	2.075	0.826	53.3	
9	A	244	2.678	1.429	29.8	
	B	246	2.819	1.570	32.7	31.1
	C	236	2.730	1.481	30.9	
10	A	253	3.095	1.846	33.1	
	B	278	3.340	2.091	37.5	34.6
	C	258	3.101	1.852	33.2	
11	A	265	3.158	1.909	39.5	
	B	264	3.171	1.922	39.8	41.7
	C	250	3.458	2.209	45.7	
12	A	261	3.491	2.242	40.0	
	B	254	3.162	1.913	34.1	39.0
	C	278	3.647	2.398	42.8	
13	A	258	2.762	1.513	30.7	
	B	218	2.562	1.313	26.6	27.5
	C	217	2.489	1.240	25.2	
14	A	245	2.946	1.697	29.8	
	B	243	3.023	1.774	31.1	29.5
	C	233	2.818	1.569	27.5	
15	A	270	3.158	1.909	30.2	
	B	266	2.912	1.663	26.3	28.7
	C	273	3.128	1.879	29.7	
16	A	281	3.422	2.173	30.6	
	B	272	3.238	1.989	28.0	27.4
	C	245	2.925	1.676	23.6	
17	A	158	1.761	0.512	31.6	
	B	167	1.871	0.622	38.4	33.5
	C	151	1.743	0.494	30.5	
18	A	152	1.595	0.346	22.3	
	B	160	1.757	0.508	32.8	30.0
	C	159	1.788	0.539	34.9	
19	A	208	2.607	1.358	23.5	
	B	230	2.736	1.487	25.8	24.4
	C	215	2.633	1.384	24.0	
20	A	245	2.756	1.507	26.5	
	B	241	2.643	1.394	24.6	27.2
	C	245	2.997	1.748	30.7	

A comparison of the total yields of dry matter and of nitrogen in both crops shows a satisfactory agreement in the parallels of each series. Wide variations occur but occasionally, the most marked of these being in series 5, where the yield of nitrogen, in cylinder C, was 1.931 grams as against 2.369 grams in cylinder A; in series 16, where the yield of nitrogen, in cylinder C, was 2.925, while the yield in cylinder A was 3.422 grams; or in series 18, where the yield of nitrogen was .539 grams in cylinder C and only .346 grams in cylinder A. Similar discrepancies, in some cases even more pronounced, occur in the yields of dry matter. In series 3 the yield of dry matter was 209 grams in cylinder C as against 237 grams in cylinder A; in series 5 the corresponding yields were 183 grams and 230 grams, respectively; and in series 13 the yield of dry matter was 213 grams in cylinder B as against 253 grams in cylinder A. The greatest variations in the increase over the check plot are shown again in series 5, with a variation of .438 grams of nitrogen from C to A; in series 16 with a variation of .497 grams of nitrogen from C to A, and in series 18 with a proportionately large variation for this series of .193 grams of nitrogen from A to C. It will also be noted that in ten out of the twenty series soil C showed the smallest yield of dry matter in the corresponding series, and the smallest yield of nitrogen in eight out of the twenty series. Cylinder A showed the smallest yield of dry matter in six out of the twenty series, and the smallest yield of nitrogen in seven out of the twenty series.

The Average Yield in Both Crops.

Series.	Dry Matter. gms.	Nitrogen. gms.	Nitrogen Recovered. Per cent.
1	68.3	.923	....
2	118.6	1.249	....
3	220.7	2.263	25.2
4	248.0	2.739	36.8
5	206.7	2.116	20.9
6	249.3	2.771	27.4
7	149.7	1.696	57.3
8	171.0	2.052	51.8
9	242.0	2.742	31.1
10	263.0	3.179	34.6
11	259.6	3.262	41.7
12	262.6	3.433	39.0
13	227.7	2.604	27.5
14	240.3	2.929	29.5
15	269.7	3.066	28.7
16	266.0	3.195	27.4
17	157.0	1.792	33.5
18	157.0	1.713	30.0
19	217.6	2.659	24.4
20	243.6	2.799	27.2

When the two crops are taken together the average yield of dry matter and of nitrogen is found to be greater in every case in the even series 4, 6, 8, 10, 12, 14 and 16, as compared with the corresponding odd series 3, 5, 7, 9, 11, 13 and 15. The solid manure, fresh, whether used alone or in combination, did not yield as much nitrogen to the crops as did the solid and liquid manure, fresh, under the same conditions. Similarly, the solid, leached, did not yield as much nitrogen to the crops as did the solid and liquid, leached. The total yield of dry matter and of nitrogen in the fresh-manure series exceeded that in the leached-manure series more strikingly in the case of the nitrogen than in the case of the dry matter, and that notwithstanding the comparatively large application of nitrogen in the solid and liquid portion of the leached manure in series 6, 15 and 16. The total yield of dry matter was the same in series 17 and 18, while the total yield of nitrogen was 1.792 grams in series 17 as against 1.713 grams in series 18, showing the corresponding recoveries of 33.5 per cent. and 30.0 per cent. for the two series. Where the ammonium sulphate and dried blood are used in combination with the solid, leached, viz., in series 19 and 20, the latter shows a higher yield of both dry matter and of nitrogen and a recovery of 27.2 per cent. as against 24.4 per cent. for the ammonium sulphate and leached manure. The yield of dry matter in series 8 was 171.0 grams, and of nitrogen 2.052 grams, showing an availability of 51.8 per cent., whereas the corrsponding availabilities for ammonium sulphate nitrogen and of dried blood nitrogen were 33.5 per cent. and 30.0 per cent., respectively.

The Oat Crop of 1905.

After the residual corn crop was harvested in the fall of 1904, the cylinder soils were allowed to remain bare during the succeeding winter. In the following spring the soil was again thoroughly spaded preparatory to the seeding of the oats, the second oat crop of the present rotation, and the fourth of its kind since the beginning of the cylinder experiments, in 1898.

The Manures Used.

The manures used in 1905 were obtained in the customary manner, and because of the similar origin did not show wide variation in composition from the samples used on previous occasions.

THE COMPOSITION OF THE SOLID AND LIQUID PORTIONS OF COW MANURE FRESH.

As noted in former reports, care was taken in the collection of the manures to provide for greater uniformity in composition by excluding litter or other foreign substances. This also assured a more uniform decomposition of the manure after its application, an important consideration in an experiment of this character. After its collection the material was carefully mixed, a representative sample was drawn, determinations were made on the same day, and the manure was applied on the following day, thus excluding appreciable changes in composition between the date of analysis and the date of application.

The solid, fresh, applied in 1905 had the following composition:

Fresh Manure, Solid.

	1905.	Average of eight other samples.
Water	83.738	85.023
Ash	2.395	2.241
Organic matter	13.867	12.736
Nitrogen (total)	0.349	0.340
" water soluble	0.058	0.062
" as nitrate	Trace.	0.005
" as ammonia	0.029	0.022
" as soluble organic	0.029	0.035
" as insoluble organic	0.291	0.278
Phosphoric acid	0.243	0.336
Potash	0.167	0.196

The sample of 1905 was slightly drier than the average of the other samples, and correspondingly richer in ash and organic matter. It also showed a slightly higher content of total nitrogen and a lower content of phosphoric acid and of potash. Its proportion of water-soluble nitrogen was somewhat smaller than that in the average of the other samples, while its proportion of insoluble organic nitrogen was appreciably larger. As compared with the corresponding sample of 1904, it was markedly poorer in total and water-soluble, and richer in phosphoric acid and potash, as well as in total ash and organic matter.

Fresh Manure, Solid and Liquid.

	1905.	Average of eight other samples.
Water	85.697	87.405
Ash	1.916	2.046
Organic matter	12.387	10.549
Nitrogen (total)	0.431	0.444
" water soluble	0.172	0.230
" as nitrate	Trace.	0.005
" as ammonia	0.077	0.109
" as soluble organic	0.095	0.116
" as insoluble organic	0.259	0.214
Phosphoric acid	0.223	0.265
Potash	0.256	0.422

Like the sample of solid, fresh, the present sample was drier than the average of the others. It was, at the same time, poorer in ash, but considerably richer in organic matter. Its content of total nitrogen was but slightly less than in the average of the other eight samples; its content of water-soluble nitrogen very considerably less, and its content of soluble organic nitrogen markedly higher. It might have been expected, therefore, that, everything being equal, this sample would yield a slighter proportion of available nitrogen than was yielded by previous samples. As a matter of fact, the availability of the solid and liquid, fresh, for 1905, was less than the availability of the corresponding sample for 1904, as will be seen subsequently. The sample of 1905 was also poorer in phosphoric acid, and markedly poorer in potash. As compared with the samples of 1904, it contained only 0.172 per cent. of water-soluble nitrogen as against 0.248 per cent. in the latter, only 0.095 per cent. of soluble organic as compared with 0.205 per cent. in the latter, and only 0.431 per cent. of total nitrogen as compared with 0.476 per cent. in the latter. Its content of phosphoric acid was 0.223 per cent. as against only 0.130 per cent. in the sample of 1904, and its content of potash 0.256 per cent. as against 0.455 per cent. in the sample of 1904. The latter differences are very marked, but could in themselves exert no influence on the yield of crop, since an excess of phosphoric acid and of potash was already provided for by the application of acid phosphate and of muriate. On the other hand, the differences in the proportionate amounts of the various nitrogen compounds did undoubtedly exert an influence on the growth and yield of the oat crop.

It should also be noted here that the sample of 1905 was markedly richer in organic matter than was the average of the other eight samples, and still more so than the sample of 1904, which contained only 9.586 per cent. of organic matter as against 12.387 per cent. in the sample of 1905. This difference deserves mention here, since the amount and quality of the organic matter applied to the soil exerts a direct influence on the character of the bacterial flora in the soil, and, therefore, also affects the rate of decomposition of the soil humus and the availability of the organic nitrogenous compounds utilized by the growing crop.

THE COMPOSITION OF THE SOLID, AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, LEACHED.

The fresh manures were exposed for leaching on February 16th, and sampled again before being used on April 14th, 1905. The length and time of exposure were therefore practically the same as in 1904. During this time the 100 pounds of the solid, fresh, were reduced to eighty-seven pounds, while the 100 pounds of solid and liquid, fresh, to 70.5 pounds. The corresponding weights for 1904 were seventy-nine pounds and sixty-two pounds, respectively, showing thus a slighter shrinkage for 1905. The following tabulation represents the composition of the fresh and of the corresponding leached manures:

Solid, Fresh, Previous to and After Leaching.

	Fresh.	Leached.
Water	82.581	80.886
Ash	2.185	2.518
Organic matter	15.234	16.596
Nitrogen (total)	0.338	0.393
" water soluble	0.054	0.066
" as nitrate	0.000	Trace.
" as ammonia	0.029	0.035
" as soluble organic	0.025	0.031
" as insoluble organic	0.284	0.327
Phosphoric acid	0.276	0.261
Potash	0.202	0.153

A comparison of the leached and fresh materials shows that the eighty-seven pounds of the former contained a smaller proportion of water and a larger proportion of ash and of organic matter than the original material. The proportionate content of total nitrogen, of water-soluble nitrogen and of ammonia nitrogen, had also increased. The increase of insoluble organic nitrogen was more marked, however, than that in the other forms of nitrogen. There was a decrease in the proportionate content of both the phosphoric acid and the potash, especially in the case of the latter, whose percentage was reduced from 0.202 in the fresh manure to 0.153 in the leached manure:

Solid and Liquid, Fresh, Previous to and After Leaching.

	Fresh.	Leached.
Water	85.349	80.647
Ash	2.075	2.418
Organic matter	12.576	16.935
Nitrogen (total)	0.500	0.508
" water soluble	0.242	0.167
" as nitrate	0.000	Trace.
" as ammonia	0.163	0.119
" as soluble organic	0.079	0.048
" as insoluble organic	0.258	0.341
Phosphoric acid	0.249	0.291
Potash	0.198	0.167

Also, in the solid and liquid portion there was a proportionate as well as an absolute decrease in several of the constituents. The moisture was reduced from 85.349 per cent. to 80.647 per cent.; the water-soluble nitrogen from 0.242 per cent. to 0.167 per cent.; the ammonia nitrogen from 0.163 to 0.119 per cent., and the potash from 0.198 per cent. to 0.167 per cent. On the other hand, there was a proportionate increase from 0.500 per cent. to 0.508 per cent. in total nitrogen; from 0.258 per cent. to 0.341 per cent. in insoluble organic nitrogen; from 0.249 per cent. to 0.291 per cent. in phosphoric acid; from 2.075 per cent. to 2.418 per cent. in ash, and from 12.576 per cent. to 16.935 per cent. in dry matter.

Application of the Manures and Fertilizers.

The customary application of twenty grams of acid phosphate and of ten grams of muriate was made in each cylinder, with the exception of those in series 1. The odd series, 7, 9, 11, 13 and 15, received, as usual, five grams of sodium nitrate per cylinder, while the corresponding soils in the even series, 8, 10, 12, 14 and 16, each received ten grams of nitrate. Equivalent quantities of nitrogen to that in the even series were applied as ammonium sulphate in series 17 and 19, and as dried blood in series 18 and 20. The quantities of manure applied were, of solid, fresh, two pounds eight ounces, containing 3.96 grams of nitrogen; of solid and liquid, fresh, two pounds one ounce, containing 4.03 grams of nitrogen; of solid, leached, two pounds four ounces, containing 4.01 grams of nitrogen; and of solid and liquid, leached, one pound twelve ounces, containing 4.03 grams of nitrogen. The application of these materials was made on April 19th. During the growing season water was applied from the hose in equal amounts on all the cylinders whenever the soils seemed to need it.

The Crops Grown.

The crops of 1905 were the same as those of 1904, viz., oats, followed by corn. The number of seeds and the method of seeding were the same as in the preceding season. The oat crop made good growth in all the cylinders with the exception of those in series 1 and 2, where the development of the plants was retarded. The entire crop was harvested on July 2d, and after thorough air-drying was analysed.

Oats, 1905.

	Nitrogen applied.	Air-dry matter in crop.	Nitrogen in air-dry matter.	Nitrogen in crop.	Increase over check plot.	Per cent. of nitrogen recovered.	Average.
	gms.	gms.	%	gms.	gms.	%	%
1 A		53	1.270	0.673			
B		41	1.699	0.696			
C		44	1.488	0.655			
2 A		70	1.080	0.756			
B		70	1.084	0.759	(0.747)		
C		67	1.084	0.726			
3 A	3.96	116	1.155	1.340	0.593	15.0	
B		113	1.077	1.217	0.470	11.9	15.4
C		132	1.145	1.511	0.764	19.3	
4 A	4.03	167	1.127	1.882	1.135	28.2	
B		166	1.077	1.788	1.041	25.8	28.0
C		168	1.162	1.952	1.205	29.9	
5 A	4.01	134	1.030	1.380	0.633	15.8	
B		125	1.077	1.346	0.599	14.9	16.3
C		130	1.134	1.474	0.727	18.1	
6 A	4.03	157	1.170	1.837	1.090	27.0	
B		150	1.098	1.647	0.900	22.3	23.0
C		145	1.062	1.540	0.793	19.7	
7 A	0.77	122	1.123	1.370	0.623	80.9	
B		133	1.098	1.460	0.713	92.6	86.4
C		124	1.134	1.406	0.659	85.6	
8 A	1.55	156	1.230	1.919	1.172	75.6	
B		168	1.152	1.935	1.188	76.6	76.9
C		162	1.211	1.962	1.215	78.4	
9 A	4.78	162	1.184	1.918	1.171	24.8	
B		161	1.201	1.934	1.187	25.1	24.3
C		153	1.195	1.828	1.081	22.9	
10 A	5.51	183	1.359	2.487	1.740	31.6	
B		193	1.302	2.513	1.766	32.0	31.3
C		180	1.345	2.421	1.674	30.4	
11 A	4.80	200	1.341	2.682	1.935	40.3	
B		207	1.266	2.621	1.874	39.0	37.8
C		182	1.309	2.382	1.635	34.1	
12 A	5.58	186	1.488	2.768	2.021	36.2	
B		190	1.552	2.949	2.202	39.5	37.5
C		206	1.363	2.808	2.061	36.9	
13 A	4.78	150	1.180	1.770	1.023	21.4	
B		159	1.187	1.887	1.140	23.8	23.6
C		160	1.237	1.979	1.232	25.7	
14 A	5.56	180	1.309	2.356	1.609	29.0	
B		179	1.295	2.318	1.571	28.3	28.6
C		172	1.356	2.332	1.585	28.5	
15 A	4.80	180	1.296	2.331	1.584	33.0	
B		187	1.237	2.313	1.566	32.6	32.6
C		179	1.280	2.291	1.544	32.2	
16 A	5.58	204	1.424	2.905	2.158	38.7	
B		194	1.363	2.644	1.897	34.0	35.3
C		191	1.363	2.603	1.856	33.3	
17 A	1.62	149	1.208	1.800	1.053	65.0	
B		138	1.176	1.623	0.876	54.1	57.0
C		126	1.259	1.586	0.839	51.8	
18 A	1.57	102	1.104	1.126	0.379	24.1	
B		100	1.183	1.183	0.386	24.6	25.6
C		105	1.188	1.190	0.443	28.2	
19 A	5.63	169	1.334	2.254	1.507	26.7	
B		165	1.298	2.142	1.395	24.7	25.1
C		150	1.392	2.088	1.341	23.8	
20 A	5.56	146	1.302	1.901	1.154	20.7	
B		158	1.212	1.915	1.168	20.9	20.1
C		159	1.122	1.784	1.037	18.6	

The above table shows, on the whole, a very gratifying agreement in the parallels of the several series. In some of these the variations are very slight, as, for example, in series 2, where the greatest variation is from 67 to 70 grams; in series 4, where the greatest variation is from 166 to 168 grams; and in series 18, where the greatest variation is from 100 to 105 grams. Series 3, on the other hand, shows a maximum variation of nineteen grams; series 11, a maximum variation of twenty-five grams; series 12, a maximum variation of twenty grams; series 17, a maximum variation of twenty-three grams, and series 19, a maximum variation of nineteen grams. All of these variations are in the yield of dry matter. The yields of nitrogen show, in most cases, even a more satisfactory agreement. Thus the maximum variation in series 1 is from 0.655 grams to 0.696 grams; in series 2, from 0.726 grams to 0.759 grams; in series 4, from 1.788 grams to 1.952 grams; in series 8, from 1.919 grams to 1.962 grams; in series 10, from 2.421 grams to 2.513 grams; in series 14, from 2.318 grams to 2.356 grams; in series 15, from 2.291 to 2.331 grams, etc. There is a very gratifying agreement in series 8, used as the basis of calculation in determining the availabilities of the manure, when used in combination with the nitrogen salts. The availability of the nitrate nitrogen as based on the recovery varied from 89.9 per cent. to 92.6 per cent., in series 7, where the single quantity of nitrate was used, and from 75.6 to 78.4 per cent. in series 8, where the double quantity was applied. The availability of the ammonium sulphate nitrogen varied from 51.8 to 65.0 per cent., and the availability of the dried blood nitrogen from 24.1 to 28.2 per cent. The availability in the solid, fresh, varied from 11.9 per cent. to 19.3 per cent.; of the solid and liquid, fresh, from 25.8 per cent. to 29.9 per cent.; of the solid, leached, from 14.9 to 18.1 per cent., and of the solid and liquid, leached, from 19.7 to 27.0 per cent. In the combinations of manure and nitrate the availabilities ranged, in most cases, above 30 per cent. The combinations in series 9, 13 and 14 showed, on the other hand, availabilities of less than 30 per cent.:

Average Composition of the Crop.

Series.	Dry Matter. gms.	Nitrogen. Per cent.	Nitrogen.* gms.
1	46.0	1.467	0.675
2	69.0	1.083	0.747
3	120.3	1.127	1.356
4	167.0	1.122	1.874
5	129.7	1.079	1.400
6	150.7	1.111	1.675
7	126.3	1.118	1.412
8	162.0	1.197	1.939
9	158.7	1.193	1.898
10	185.3	1.335	2.474
11	196.3	1.305	2.562
12	194.0	1.465	2.842
13	156.3	1.202	1.879
14	177.0	1.319	2.335
15	182.0	1.270	2.312
16	196.3	1.384	2.717
17	137.7	1.213	1.670
18	102.3	1.124	1.150
19	161.3	1.340	2.161
20	154.3	1.210	1.867

The average yield of dry matter in series 1 was considerably les than that in series 2. As in previous seasons, however, the dr matter in the former series was markedly richer in nitrogen, so tha the difference in the yield of total nitrogen was not as pronounce as was the difference in the yield of dry matter. The proportionat content of nitrogen in the dry matter from series 2 was smaller tha that in the dry matter from any other series, a fact which is in agree ment with the experience of previous seasons, and which is accounte for by the more thorough utilization of the small store of availabl nitrogen in the presence of an excess of phosphoric acid and o potash. The average yield of dry matter in series 3 was much belov that in series 4; the percentage of nitrogen in the two is practicall the same, so that there is a proportionate difference in the yield o nitrogen in the two series. The average yield of dry matter in serie 5, where the solid, leached, was applied, was 129.7 grams, as agains a corresponding yield of 150.7 grams, in series 6, where the solid an liquid, leached, was applied. The proportionate content of nitroger was also higher in series 6, increasing thereby the difference in th yield of nitrogen on the two series. The average yield of dry matte

on series 7, where the single quantity of nitrate was applied, was 126.3 grams, higher than that in series 3, and slightly smaller than *that in series 5. The corresponding yield of dry matter in series 8*, where the double quantity of nitrate was used, was 162.0 grams greater than that in series 6, and almost as large as that in series 4. The *proportionate content of nitrogen in the dry matter from series* 7 was 1.118, as against 1.197 per cent. in series 8. The difference in the yield of nitrogen was thereby increased, making an average *yield of 1.412* grams for series 7, and of *1.939* grams for series 8. The corresponding yield in series 4 was only 1.874 grams, hence, notwithstanding the larger yield of dry matter, series 4 still showed a smaller yield of nitrogen than did series 8. The corresponding yields of dry matter in series 17, where ammonium sulphate was applied, and in series 18, where dried blood was applied, were 137.7 grams and 102.3 grams, respectively. The proportionate content of nitrogen in the dry matter from series 17 was greater than that in series 8, while the proportionate content of nitrogen in the dry matter from series 18 was smaller than that in series 8. The yields of nitrogen in series 8, 17 and 18 become, therefore, 1.939 grams, 1.670 grams and 1.150 grams, respectively. In the series where the manures and nitrate were used in combination, we note that the solid, fresh, when applied together with five grams of nitrate in series 9, yielded, on the average, 158.7 grams of dry matter containing 1.193 per cent. of nitrogen, as against a corresponding yield of 185.3 grams of dry matter containing 1.335 per cent. of nitrogen in series 10. The average yields of nitrogen in the two series become, therefore, 1.893 grams and 2.474 grams, respectively. The single portion of nitrate in series 11, where it was used together with the solid and liquid, fresh, yielded more dry matter than did the double portion in the corresponding series 12. At the same time, the dry matter in the latter series contained 1.465 per cent. of nitrogen as against 1.305 per cent. of nitrogen in the dry matter of series 11. The higher proportionate content of nitrogen in series 12 led to a yield of 2.842 grams of nitrogen as against the corresponding yield of 2.562 grams in series 11. The average yield of dry matter in series 13 was 1.202 per cent. and 1.319 per cent., respectively, while the absolute yield of nitrogen for the two series was 1.879 grams and 2.335 grams, *respectively. The average yield of dry matter in series 15* was 182.0 grams; that in series 16, 196.3 grams. The proportionate content of nitrogen for the two series was 1.270 per cent. and 1.384 per cent.,

respectively, and the absolute yield was 2.312 and 2.717 grams, respectively. It will be noted, also, that the double portion of nitrate applied with any of the four manures yielded dry matter richer in nitrogen than did the corresponding single portion of nitrate. Similarly, the solid and liquid, fresh, in series 11 and 12, yielded, on the average, dry matter richer in nitrogen than that produced on series 9 and 10, where the solid, fresh, was applied together with the corresponding manures. The solid and liquid, leached, in series 15 and 16, yielded dry matter richer in nitrogen than that in series 13 and 14, where the solid, leached, was used with the corresponding quantities of nitrate. The dry matter in series 19 and 20 was richer in nitrogen than was the corresponding dry matter in series 17 and 18, where the ammonium sulphate and dried blood, respectively, were used alone. On the whole, the percentage of nitrogen in the crop from the odd series, 9, 11, 13 and 15, was higher than that in the corresponding even series, 10, 12, 14 and 16.

Average Increase Over the Check Plot, and the Average Per Cent. of Nitrogen Recovered.

Series.	Increase in Yield of Nitrogen. gms.	Nitrogen Recovered. Per cent.
1	....	....
2	....	....
3	0.609	15.4
4	1.127	28.0
5	0.653	16.3
6	0.928	23.0
7	0.665	86.4
8	1.192	76.9
9	1.146	24.3
10	1.727	31.3
11	1.815	37.3
12	2.095	37.5
13	1.132	23.6
14	1.588	28.6
15	1.565	32.6
16	1.970	35.3
17	0.923	57.0
18	0.403	25.6
19	1.414	25.1
20	1.120	20.1

The average increase in the yield of nitrogen over the check plot was 0.609 grams in series 3, as compared with an increase of 1.127 grams in series 4. The corresponding average recoveries were 15.4 per cent. and 28.0 per cent., respectively. It seems, thus, that the solid and liquid, fresh, furnished almost double the amount of available nitrogen furnished by the solid, fresh. The increase in series 5 was 0.653 grams, with a recovery of 16.3 per cent., and in series 6 it was 0.928 grams, with a recovery of 23.0 per cent. These figures show the greater availability of the nitrogen in the solid and liquid, leached, as compared with that in the solid, leached, although the difference was not so great as in the case of the fresh manures. The increase in series 7 was 0.665 grams, and the recovery 86.4 per cent., as compared with an increase of 1.192 and a recovery of 76.9 per cent. in series 8. The recoveries in both series were quite high, and it appears that the nitrogen in the single portion of nitrate was more thoroughly utilized than was the nitrogen in the double portion. The equivalent amount of ammonium sulphate nitrogen in series 17 showed an increase of only 0.923 grams and a recovery of 57.0 per cent., as against the corresponding increase of 1.192 grams, and recovery of 76.9 per cent. in series 8. The equivalent quantity of nitrogen in dried blood, applied in series 18, was utilized even less thoroughly, for the increase here was only 0.403 grams and the recovery 25.6 per cent., but little higher than that in series 6, where the solid and liquid, leached, was applied. In the combinations of manure and nitrate the recovery in the even series, where the double quantity of nitrate was used, was invariably higher than that in the odd series, where the single quantity was applied. The difference is greatest between series 9 and 10, where the increase was 1.146 grams and 1.727 grams, respectively, and the recoveries 24.3 per cent. and 31.3 per cent., respectively. The difference is smallest between series 11 and 12, the increase being 1.815 grams and 2.095 grams, respectively, and the recoveries 37.3 and 37.5 grams, respectively. In the combinations of nitrate with solid, leached, the single portion of nitrate led to an increase of 1.132 grams and the double portion to an increase of 1.588 grams, the respective recoveries being 23.6 and 28.6 per cent. The corresponding increase from the solid and liquid, leached, and nitrate, was 1.565 in series 15, and 1.970 in series 16, the corresponding recoveries being 32.6 and 35.6 per cent., respectively. It appears, thus, that the double application of nitrate in the combinations favored a more thorough utilization

of the nitrogen applied than did the single portion of nitrate, and that notwithstanding the fact that the relations were reversed when the nitrate was applied alone. The application of ammonium sulphate and of dried blood together with the solid, leached, in series 19 and 20, respectively, also increased the proportionate recovery from the materials used. The increase in series 19 was 1.414 grams and the recovery 25.1 per cent., as against an increase of 1.588 and a recovery of 28.6 in series 14, where the equivalent quantity of nitrate nitrogen was used together with the manure. Similarly, the dried blood and solid, leached, in series 20, showed a recovery of 20.1 per cent., whereas the recovery from the dried blood alone was only 25.6 per cent., and the recovery from the ammonium sulphate only 57.0 per cent., as against the corresponding recovery of 76.9 per cent. in series 8.

The Corn Crop, 1905.

The oats were harvested on July 2d, the soil was thoroughly spaded and the corn planted as in the preceding season without the further application of nitrogenous materials. As on other occasions, this crop was intended for the exhaustion of the available nitrogen from the cylinder soils and the collection of the nitrogen gradually rendered available during the remainder of the growing season. It was to be expected that in the case of the soluble nitrates the first crop had left but little of it in the soil. The same is true to a more limited extent of the readily nitrifiable nitrogen in the ammonium sulphate, dried blood and in the liquid portion of the fresh manure. The solid manure, fresh, on the other hand, because of its gradual decomposition, yielded less to the first crop than did the solid and liquid, fresh, and hence could furnish more to the residual crop. Similarly, in the combinations of manure and nitrate, it was to be expected, from the theoretical standpoint, that the odd series, 9, 11, 13 and 15, having shown a slighter recovery than the even series, 10, 12, 14 and 16, would make a proportionately better showing in the residual crop, and that the combination of manure and dried blood in series 20 would, for the same reason, make a better showing than the combination of manure and ammonium sulphate.

The Corn Crop, 1905.

	Residual nitrogen.	Air-dry matter in crop.	Nitrogen in air-dry matter	Nitrogen in crop.	Increase over check plot.	Per cent of nitrogen recovered.	Average.
	gms.	gms.	%	gms.	gms.	%	%
1 A	....	43	1.116	0.480	....	....	....
1 B	....	48	1.114	0.535	....	....	....
1 C	....	42	1.184	0.497	....	....	....
2 A	....	64	0.847	0.542	....	....	....
2 B	....	61	0.977	0.596	(0.530)	....	....
2 C	....	45	1.005	0.452	....	....	....
3 A	3.37	102	0.852	0.869	0.339	10.1	....
3 B	3.49	154	0.786	1.210	0.680	19.5	12.2
3 C	3.21	79	0.959	0.758	0.228	7.1	....
4 A	2.89	108	0.793	0.856	0.326	11.3	....
4 B	2.99	96	0.813	0.780	0.250	8.4	7.3
4 C	2.82	65	0.916	0.595	0.065	2.3	....
5 A	3.38	132	0.846	1.117	0.587	17.3	....
5 B	3.41	129	0.803	1.036	0.506	14.8	15.8
5 C	3.28	120	0.856	1.027	0.497	15.2	....
6 A	2.94	112	0.838	0.938	0.408	13.9	....
6 B	3.13	115	0.852	0.980	0.450	14.4	13.0
6 C	3.24	95	0.923	0.877	0.347	10.7	....
7 A	0.15	58	0.856	0.496	0.034	....	....
7 B	0.06	49	0.884	0.433	0.097	....	5.5
7 C	0.11	52	1.030	0.536	0.006	5.5	....
8 A	0.38	68	0.884	0.601	0.071	18.7	....
8 B	0.36	58	0.838	0.486	0.044	....	13.4
8 C	0.33	56	0.994	0.557	0.027	8.2	....
9 A	3.56	138	0.852	1.176	0.646	18.1	....
9 B	3.54	112	0.870	0.974	0.444	12.5	14.1
9 C	3.65	98	0.976	0.956	0.426	11.7	....
10 A	3.77	85	1.061	0.902	0.372	9.9	....
10 B	3.74	184	0.834	1.534	1.004	26.8	17.4
10 C	3.84	127	0.887	1.126	0.595	15.6	....
11 A	2.86	107	0.822	0.879	0.349	12.2	....
11 B	2.93	157	0.820	1.287	0.757	25.8	17.0
11 C	3.16	100	0.940	0.940	0.410	13.0	....
12 A	3.56	122	0.834	1.017	0.487	13.7	....
12 B	3.38	127	0.866	1.100	0.570	16.9	15.2
12 C	3.52	111	0.955	1.060	0.530	15.1	....
13 A	3.76	120	0.866	1.039	0.509	13.5	....
13 B	3.64	114	0.799	0.911	0.381	10.5	11.7
13 C	3.55	109	0.849	0.925	0.395	11.1	....
14 A	3.95	131	0.944	1.237	0.707	17.9	....
14 B	3.99	129	0.806	1.040	0.510	12.8	13.0
14 C	3.97	100	0.856	0.856	0.326	8.2	....
15 A	3.22	130	0.799	1.039	0.509	15.8	....
15 B	3.23	111	0.895	0.993	0.463	14.3	15.1
15 C	3.26	113	0.906	1.023	0.493	15.1	....
16 A	3.42	126	0.817	1.029	0.499	14.6	....
16 B	3.68	150	0.824	1.236	0.706	19.2	15.9
16 C	3.72	113	0.926	1.046	0.516	13.9	....
17 A	0.57	58	0.866	0.502	0.028	....	....
17 B	0.74	71	0.902	0.640	0.110	14.9	14.3
17 C	0.78	64	0.997	0.638	0.108	13.8	....
18 A	1.19	116	0.792	0.919	0.389	32.7	....
18 B	1.18	91	0.831	0.756	0.226	19.1	2.15
18 C	1.13	69	0.976	0.673	0.143	12.6	....
19 A	4.12	118	0.852	1.005	0.475	11.5	....
19 B	4.28	117	0.866	1.013	0.483	11.4	11.4
19 C	4.29	106	0.958	1.015	0.485	11.3	....
20 A	4.43	156	0.852	1.329	0.799	18.0	....
20 B	4.41	144	0.834	1.201	0.671	15.2	17.0
20 C	4.54	139	0.958	1.332	0.802	17.7	....

The above table shows on the whole a good agreement among the parallels, also, of this crop. It will be noted, however, that the variations here are greater than those in the oat crop. It will likewise be noted that the differences in the residual crop are partly compensated by those in the first crop and *vice versa*. For instance, there was a yield of 132 grams of dry matter and 1.511 grams of nitrogen in soil C of series 3 in the oat crop, whereas the corresponding yields of dry matter in soils A and B were 116 grams and 113 grams, respectively. In the residual corn crop soil C, of series 3, yielded only seventy-nine grams of dry matter as against the corresponding yields of 102 grams and 154 grams, respectively. We find similar compensations in series 12, series 13 and series 20. On the other hand, there are series where a relatively large yield of nitrogen in the first crop is followed also by a relatively large yield in the residual crop, as, for example, in series 10 and series 15. The variations in the dry matter in the residual crop are also frequently compensated by inverse variations in the percentage of nitrogen. Thus the corn crop from cylinder C, in series 1, weighing only forty-two grams, contains none the less a greater absolute quantity of nitrogen than does the crop from cylinder A of the same series, even though the latter weighed forty-three grams. Similarly, the crop from cylinder C, series 7, weighed fifty-two grams and contained 0.536 grams of nitrogen, whereas the crop from cylinder A weighed fifty-eight grams and contained only 0.496 grams of nitrogen. Similar compensations are found in series 12, 13, 16, 17, etc. Considerable variations are found in the recoveries from the residual nitrogen, as, for example, in series 4, where there is a variation from 23 per cent. to 11.3 per cent.; in series 10, where there is a variation from 9.9 per cent. to 26.8 per cent.; in series 11, where there is a variation from 12.12 per cent. to 25.8 per cent., etc.

Average Composition of the Corn Crop.

Series.	Dry Matter. gms.	Nitrogen. Per cent.	Nitrogen. gms.
1	44.3	1.138	0.504
2	56.7	0.935	0.530
3	111.7	0.847	0.946
4	89.7	0.829	0.744
5	127.0	0.834	1.060
6	107.3	0.868	0.932
7	53.0	0.921	0.488
8	60.7	0.903	0.548
9	116.0	0.892	1.035
10	132.0	0.899	1.187
11	121.3	0.853	1.035
12	120.0	0.882	1.059
13	114.3	0.838	0.958
14	120.0	0.870	1.044
15	118.0	0.863	1.018
16	129.7	0.851	1.104
17	64.3	0.922	0.593
18	92.0	0.851	0.783
19	113.7	0.889	1.011
20	146.3	0.879	1.287

The dry matter in series 1 still contained a higher percentage of nitrogen than did the dry matter in series 2. The amount of dry matter produced in series 2 still exceeded that produced in series 1, and the total yield of nitrogen was slightly greater in series 2. The percentage of nitrogen in the dry matter from series 2 was 0.935, higher than that in any other series with the exception of series 1. It will be remembered that in the first crop the percentage of nitrogen in the dry matter from series 2 was, with one exception, the lowest of any, and the attempt was made to explain this condition by the assumption that the comparatively slight quantity of available nitrogen in the soils of series 2 was utilized to the utmost extent. In the residual crop the quantity of available nitrogen in series 2 was still smaller; nevertheless, the percentage of nitrogen in the dry matter from this series was higher than that from soils provided with a greater quantity of available nitrogen. This contradiction may be explained by the well-known fact that in soils where the quantity of available nitrogen is very slight the development of the plants is sufficiently retarded to preclude a thorough utilization of whatever soil-nitrogen is placed at their disposal. In the present instance this is corroborated by the high percentage of nitrogen in the dry matter

from series 7, 8 and 17, whose soils were quite depleted of available nitrogen by the preceding oat crop.

It will be observed that the average yield of dry matter in series 3 was 111.7 grams, containing 0.847 per cent. of nitrogen, and a total quantity of the latter of 0.946 grams. In series 4, where the solid and liquid, fresh, was applied for the preceding crop, the average yield of dry matter was only 89.7 grams, containing 0.829 per cent. of nitrogen, and a total quantity of the latter of 0.744 grams. Evidently the relations in the first crop are reversed in the residual crop. The residues from the solid, fresh, led to the production, not only of more dry matter and of nitrogen, but also of dry matter richer in nitrogen than that produced from the residues in the solid and liquid, fresh.

The solid, fresh, supplied more nitrogen to the residual crop than did the solid and liquid, fresh, thus again *reversing the relations* observed in the first crop. Moreover, the residues in the solid, leached, yielded more nitrogen to the corn crop than did the residues in the solid, fresh; and the residues in the solid and liquid, leached, yielded more nitrogen to the corn crop than did the residues in the solid and liquid, fresh.

The average yield of dry matter in series 7 was 53.0 grams, and the yield in series 8, 60.7 grams. The percentage of nitrogen in the dry matter from series 7 was 0.921, and that in the dry matter from series 8, 0.903. The total average yield of nitrogen in these series was 0.488 grams and 0.548 grams, respectively. It will be seen, thus, that the average yield of dry matter and of nitrogen in series 7 was actually less than the corresponding yield in series 2, and that the average yield of dry matter and of nitrogen in series 8 was not much greater than the corresponding yield in series 2. Also, in series 17 there were only 64.3 grams of dry matter, elaborated in the residual crop from each cylinder, and if it were not for the high percentage of nitrogen in the crop from series 17 the total yield of nitrogen in this series would have hardly been greater than that in series 2. On the other hand, the residual effect of the dried blood in series 18 was decidedly more pronounced than that in series 8 and 17. The production of dry matter in series 18 exceeded that in series 8 by one-half, and that in series 17 by almost as much. The average yield of nitrogen in series 18 was 0.783 grams, considerably

larger than the corresponding yield of 0.593 grams in series 17, and of 0.548 grams in series 8.

The residual effects from the combinations of nitrate and manures, in series 9 to 17, also deserve a careful study. It will be noted that the average yield of dry matter was, with one exception, greater in the even series, 10, 12, 14 and 16, than it was in the corresponding odd series, 9, 11, 13 and 15. The yield of nitrogen in the even series was, without exception, greater in each case than it was in the corresponding odd series. Also, the percentage of nitrogen was, with one exception, greater in the dry matter from the even series than it was in the dry matter from the corresponding odd series. Comparing the yields in the corresponding series 9 and 11, we note that the average yield of dry matter in the former was 116.0 grams, and in the latter 121.3 grams, the total average yield of nitrogen in the two being the same, viz., 1.035 grams each. In series 10 the average yield of dry matter was 132.0 grams, and of nitrogen 1.187 grams, as compared with the corresponding yields of 120.0 grams and of 1.059 grams, respectively. It seems, thus, that the double quantity of nitrate, when applied together with the solid and liquid, fresh, allowed a more thorough utilization of the various nitrogen compounds, by the first crop, leaving a slighter amount of nitrogen to be rendered available to the residual crop. The solid, leached, and the five grams of nitrate, in series 13, gave a residual yield of 114.3 grams of dry matter and of 0.958 grams of nitrogen. The solid and liquid, leached, with the same amount of nitrate, in series 15, gave a residual yield of 118.0 grams of dry matter and of 1.018 grams of nitrogen. The solid, leached, with the ten grams of nitrate, in series 14, gave a residual yield of 120.0 grams of dry matter, and of 1.044 grams of nitrogen. The solid and liquid, leached, with the ten grams of nitrate, in series 16, gave a residual yield of 129.7 grams of dry matter, and of 1.104 grams of nitrogen. Hence the solid, leached, when used in combination with either five or ten grams of sodium nitrate, gave a lower residual yield of dry matter and of nitrogen than did the corresponding combination of nitrate and of the solid and liquid, leached.

In the combinations of the solid, leached, and of ammonium sulphate, on the one hand, and of the solid, leached, and of dried blood, on the other, the residual yields were 113.7 grams and 146.3 grams, respectively, of dry matter, and 1.011 grams and 1.287 grams, re-

spectively, of nitrogen. The corresponding yields in series 14, where the solid, leached, was used in combination with an equivalent quantity of nitrate, the yields of dry matter and of nitrogen were 120.0 grams and 1.044 grams, respectively. It seems, therefore, that the residual yield of dry matter from the nitrate combination was somewhat greater than that from the ammonium sulphate combination, while the corresponding yield of nitrogen from the nitrate combination was slightly greater than that from the ammonium sulphate combination. On the other hand, the residual yield of dry matter from the dried blood combination was much greater than the corresponding yield from the nitrate combination, as was also true of the nitrogen yield. In general, the residual yield of both dry matter and of nitrogen from the dried blood combination was greater than that from any other series.

The total average yield of dry matter from the fresh manure combinations, in series 9, 10, 11 and 12, was 489.3 grams, and the corresponding yield from the leached manure combinations in series 13, 14, 15 and 16, was 482.0 grams. The total average yield of nitrogen in the four series, 9, 10, 11 and 12, was 4.316 grams, and the corresponding yield in series 13, 14, 15 and 16 was 4.124 grams, a difference both of dry matter and of nitrogen in favor of the fresh manure combinations. Where the manures were used alone the relations are reversed, for the total average yield in series 3 and 4 was 201.4 grams of dry matter and 1.690 grams of nitrogen, whereas the corresponding yields in the leached manure series 5 and 6 were 234.0 grams and 1.992 grams, respectively.

The Average Increase Over the Check Plot, and the Average Per Cent. of Nitrogen Recovered.

Series.	Average Increase. gms.	Nitrogen Recovered. Per cent.
1	....	....
2	....	....
3	0.416	12.2
4	0.214	7.3
5	0.530	15.8
6	0.402	13.0
7	....	....
8	....	....
9	0.505	14.1
10	0.657	17.4
11	0.505	17.0
12	0.529	15.2
13	0.428	11.7
14	0.514	13.0
15	0.488	15.1
16	0.574	15.9
17	....	....
18	0.253	21.5
19	0.481	11.4
20	0.757	17.0

The Combined Yield of the Two Crops of 1905.

		Dry matter in crop.	Nitrogen in crop.	Increase over check plot.	Per cent. of nitrogen recovered.	Average.
		gms.	gms.	gms.	%	%
1	A	95	1.152			
	B	89	1.231			
	C	86	1.152			
2	A	134	1.298			
	B	131	1.355	(1.277)		
	C	112	1.178			
3	A	218	2.209	0.932	23.5	
	B	267	2.427	1.150	29.0	25.9
	C	211	2.269	0.992	25.1	
4	A	275	2.738	1.461	36.3	
	B	262	2.568	1.291	32.0	33.3
	C	233	2.547	1.270	31.5	
5	A	266	2.497	1.220	30.4	
	B	254	2.382	1.105	27.6	29.5
	C	250	2.501	1.224	30.5	
6	A	269	2.775	1.498	37.2	
	B	265	2.627	1.350	33.5	33.0
	C	240	2.417	1.140	28.3	
7	A	180	1.866	0.589	76.5	
	B	182	1.893	0.616	80.0	81.0
	C	176	1.942	0.665	86.4	
8	A	224	2.520	1.243	80.2	
	B	226	2.421	1.144	73.8	78.0
	C	218	2.519	1.242	80.1	
9	A	300	3.094	1.817	38.4	
	B	273	2.908	1.631	34.5	34.9
	C	251	2.784	1.507	31.9	
10	A	268	3.389	2.112	38.3	
	B	377	4.039	2.762	50.1	43.2
	C	307	3.547	2.270	41.2	
11	A	307	3.521	2.244	46.7	
	B	364	3.908	2.631	54.8	48.0
	C	282	3.322	2.045	42.6	
12	A	308	3.785	2.508	44.9	
	B	317	4.049	2.772	49.7	47.0
	C	317	3.868	2.591	46.4	
13	A	270	2.809	1.532	32.1	
	B	273	2.798	1.521	31.8	32.6
	C	269	2.904	1.627	34.0	
14	A	311	3.593	2.316	41.7	
	B	308	3.358	2.081	37.4	37.8
	C	272	3.188	1.911	34.4	
15	A	310	3.375	2.098	43.6	
	B	298	3.306	2.029	42.3	42.8
	C	292	3.314	2.037	42.4	
16	A	330	3.934	2.657	47.6	
	B	344	3.880	2.603	46.7	45.6
	C	304	3.649	2.372	42.5	
17	A	207	2.302	1.025	63.3	
	B	209	2.263	0.986	60.9	60.9
	C	190	2.224	0.947	58.5	
18	A	213	2.045	0.768	48.9	
	B	191	1.889	0.612	38.9	41.7
	C	174	1.863	0.586	37.3	
19	A	287	3.259	1.982	35.2	
	B	282	3.155	1.878	33.4	33.7
	C	256	3.103	1.826	32.4	
20	A	302	3.235	1.958	35.0	
	B	302	3.116	1.839	33.0	33.7
	C	298	3.116	1.839	33.0	

The average increase in nitrogen over the check plot was 0.416 grams and 0.214 *grams, respectively, in series 3 and 4. The former* was equivalent to 12.2 per cent. of the residual nitrogen, the latter to 7.3 per cent. of the residual nitrogen. These figures demonstrate again that the residues in the solid, fresh, yielded both absolutely and relatively a larger quantity of nitrogen than did the residues in the solid and liquid, fresh. The absolute average increase in series 5 was 0.530 grams of nitrogen, and in series 6, 0.402 grams of nitrogen. The relative utilization of the residual nitrogen was 15.8 per cent. and 13.0 per cent., respectively, for the two series. It seems, therefore, that the leached manures showed a greater increase over the check plot and a higher recovery than did the fresh manures. The *increase from the residual nitrogen in the combination series 9, 10, 11,* 12, 13, 14, 15 and 16 was rather uniform, ranging from 0.428 grams of nitrogen to 0.657 grams, and in five of these series from 0.488 grams to 0.529 grams of nitrogen. The recoveries varied from 11.7 per cent. to 17.4 per cent., and in five of these series it varied from 15.1 per cent. to 17.4 per cent. The total average increase from the fresh manure combinations exceeded that from the residues in the leached manure combinations, while the recovery in the former ranged from 14.1 to 17.4 per cent. and in the latter from 11.7 to 15.9 per cent. The increase of the check plot was 0.481 grams of nitrogen in series 19 and 0.757 grams of nitrogen in series 20. The corresponding relative recoveries were 11.4 per cent. and 17.0 per cent., respectively. Here we note again that the dried blood combination yielded more residual nitrogen to the corn crop than was yielded by any other combination, while the recovery was exceeded only in series 10.

A comparison of the yields of dry matter in the two crops will show that with two exceptions the dry matter in cylinders C of the several series was smaller than that in the corresponding cylinders A and B. The crops of other seasons do not show such, almost uniform, differences, and no explanation can be suggested that would account for the peculiar relations of the present season. It would seem at the same time that the lower yields in cylinder C may be due, in part at least, to the greater amount of shade in these cylinders. The differences in the yield of dry matter in cylinders C and A or B are frequently not inconsiderable. Thus the total yield of dry matter in cylinder C, of series 3, was 211 grams, while that in B was 267 grams. Similarly, there is a variation of forty-two grams in series 4; of forty-nine

grams in series 9; of 109 grams in series 10; of eighty-two grams in series 11; of forty-four grams in series 18, etc. The variations in the dry matter are fairly well paralleled by the variations in the yield of nitrogen, as may be seen from the above tabulations. On the whole, the yields in the several series are rather uniform, and abnormal variations are quite few. The variations in the increase over the check plot are proportionately larger. For instance, in series 3 there is a variation of 0.218 grams of nitrogen on a minimum yield of 0.932 grams of nitrogen. In series 6 there is a variation of 0.358 grams of nitrogen on a minimum yield of 1.140 grams; in series 9 there is a variation of 0.310 grams of nitrogen on a minimum yield of 1.507 grams; in series 10 there is a variation of 0.650 grams of nitrogen on a minimum yield of 2.112 grams of nitrogen. In some series, on the other hand, the yields of dry matter and of nitrogen show but slight variations. Thus in series 5 the greatest variation in the yield of dry matter is only fourteen grams; in series 7 it is six grams; in series 8 it is eight grams; in series 12 it is nine grams; in series 13 only four grams; in series 20 only four grams, etc. Similarly, in the yields of nitrogen the variations are frequently very small. For instance, in series 13 the greatest variation is 0.106 grams; in series 15 only 0.064 grams; in series 17 only 0.078 grams; in series 19 only 0.156 grams, and in series 20 only 0.114 grams. The variations in the *proportionate* amounts of nitrogen recovered in the two crops are, as a rule, rather small. The greatest and smallest recovery was in series 3, 23.5 per cent. and 29.0 per cent., respectively; in series 4 36.3 per cent. and 31.5 per cent., respectively; in series 5, 30.5 per cent. and 27.6 per cent., respectively; in series 13, 34.0 per cent. and 31.8 per cent., respectively; in series 15, 43.6 per cent. and 42.3 per cent., respectively; in series 17, 63.3 per cent. and 58.5 per cent., respectively; in series 19, 35.2 per cent. and 32.4 per cent., respectively; and in series 20, 35.0 per cent. and 33.0 per cent., respectively. The corresponding variations between 86.4 per cent. and 76.5 per cent. in series 7, and between 80.2 per cent. and 73.8 per cent. in series 8, are not large considering the high recovery from the nitrate used in these series. On the other hand, the variation between 48.9 per cent. and 37.3 per cent. in series 18, where dried blood was applied, is rather considerable. When compared with the yields of other seasons, the crop of 1905 shows, as was already noted, a gratifying uniformity among the parallel plots.

The Average Yield in Both Crops.

	Dry Matter. gms.	Nitrogen. gms.	Nitrogen Recovered. Per cent.
1	90.3	1.179	....
2	125.7	1.277	....
3	232.0	2.302	25.9
4	256.7	2.618	33.3
5	256.7	2.460	29.5
6	258.0	2.607	33.0
7	179.3	1.900	81.0
8	222.7	2.487	78.0
9	274.7	2.928	34.9
10	317.3	3.661	43.2
11	317.6	3.597	48.0
12	314.0	3.901	47.0
13	270.6	2.837	32.6
14	297.0	3.379	37.8
15	300.0	3.330	42.8
16	326.0	3.821	45.6
17	202.0	2.263	60.9
18	194.3	1.933	41.7
19	275.0	3.172	33.7
20	300.6	3.154	33.7

The differences in the yield of dry matter and of nitrogen between series 1 and 2 were already noted above. As in the single crops, the differences in the two crops combined are greater in the dry matter than they are in the nitrogen. In the case of the former the yield in series 2 exceeded that in series 1 by 28.1 per cent., and in the case of the latter by only 8.3 per cent.

The yield both of dry matter and of nitrogen was greater in series 4 than it was in series 3, showing that the greater yield from the solid and liquid, fresh, in the first crop, more than offset the greater residual yield from the solid, fresh. The recovery from the two manures was 25.9 per cent. and 33.3 per cent., respectively, a difference of more than 7 per cent. in favor of the solid and liquid, fresh. In the leached manures the yield of dry matter in series 5 was practically the same as that in series 6. In the case of the nitrogen, however, the differences were more appreciable, the solid and liquid, leached, having yielded 2.607 grams as against 2.460 grams for the solid, leached. The recoveries for series 5 and 6 were 29.5 per cent. and 33.0 per cent., respectively, a difference in favor of the solid and liquid portion of 3.5 per cent. The differ-

ence here is not as great as that in the fresh manures as should have been expected, since the leached manures varied less in composition than did the fresh manures. The total yield of dry matter from the fresh manures was 488.7 grams, and from the leached manures 514.7 grams; the total yield of nitrogen from the former was 4.920 grams, and from the latter 5.067 grams, the recoveries being 29.6 per cent. and 31.2 per cent., respectively. It thus seems that the two crops derived both absolutely and relatively more nitrogen from the leached manures than they did from the fresh manures. The yield of dry matter in series 7 was 179.3 grams, in series 8 222.7 grams, and the respective yields of nitrogen were 1.900 grams and 2.487 grams. The corresponding recoveries were 81.0 per cent. and 78.0 per cent., showing a distinct difference in favor of the five grams of nitrate as compared with the ten grams of nitrate. In series 17, where the equivalent quantity of ammonium sulphate nitrogen was applied, the yield of both dry matter and of nitrogen was very considerably less than that in series 8. Still smaller was the corresponding yield in series 18, where the equivalent quantity of nitrogen was applied as dried blood. These differences, which were far more considerable in the first crop, were only partly compensated by the greater residual yield in series 17, and more pronouncedly so in series 18. As it is, the recovery of 78.0 per cent. in series 8 compares favorably with the recovery of 60.9 per cent. in series 17, and of 41.7 per cent. in series 18.

Where the manures were used in combination with nitrate, the yields are markedly higher than they are in the series where the materials were used singly. In series 9, where the solid, fresh, was applied together with five grams of nitrate, the yields of dry matter and of nitrogen were 274.7 grams and 2.928 grams, respectively, while the corresponding yields in series 10, where ten grams of nitrate and the solid, fresh, were applied, were 317.6 grams and 3.661 grams, respectively. The corresponding recoveries for the two series were 43.2 per cent. and 48.0 per cent., showing that the soils of series 10 yielded both absolutely and relatively more nitrogen to the two crops than did the soils of series 9. In the solid and liquid manure combinations, the single portion of nitrate in series 11 led to the production of as much dry matter, or of a slightly greater quantity of dry matter, as did the double quantity of nitrate in series 12.

On the other hand, the yield of nitrogen in series 12 was markedly greater. The corresponding recoveries for the two series were 48.0 per cent. and 47.0 per cent., respectively, showing that the absolute yield of nitrogen was greater, and the proportionate utilization smaller, on series 12 than it was on series 11.

The yield of dry matter in series 13 was 270.6 grams, and of nitrogen 2.837 grams. The yield of dry matter in series 14 was 297.0 grams, and of nitrogen 3.379 grams. The recoveries for the two series were 32.6 per cent. and 37.8 per cent., respectively. It seems, therefore, that the use of the solid, leached, with ten grams of nitrate, led not only to a larger yield of dry matter and of nitrogen, but also to a relatively better utilization of the manure and nitrate nitrogen. The yield of dry matter in series 15 was 300.0 grams and of nitrogen 3.330 grams. The yield of dry matter in series 16 was was 326.0 grams and of dry matter 3.821 grams. The recoveries for the two series were 42.8 per cent. and 45.6 per cent., respectively. Also here, the double portion of the nitrate led to a more thorough, absolute and relative utilization of the manure nitrogen. Taking series 9 and 10 together, as representing the solid, fresh, combinations, and 11 and 12 together, as representing the solid and liquid, fresh, combinations, we note a better absolute and relative utilization of the solid and liquid portion. Similarly, in the case of the solid, and of the solid and liquid portions of the leached manures, we note a more thorough utilization of the latter, both proportionately and absolutely. Taking the four fresh manure combinations and the four leached manure combinations, we note that the former yielded more nitrogen to the crops, both absolutely and relatively. In series 19, where the solid, leached, was used in combination with ammonium sulphate, and in series 20, where the solid, leached, was used in combination with dried blood, the yields of dry matter were 275.0 grams and 300.6 grams, respectively, whereas in series 14, where the same manure was used with an equivalent quantity of nitrate nitrogen, the yield of dry matter was 297.0 grams—that is, greater than that in series 19 and smaller than that in series 20. The yield of nitrogen, on the other hand, was 3.379 grams in series 14, 3.172 in series 19 and 3.154 grams in series 20. The absolute yield of nitrogen was greatest from the nitrate plots and smallest from the dried blood plots. The recoveries for the three series in question were 37.8 per

cent., 33.7 per cent. and 33.7 per cent., respectively, showing the greatest proportionate yield for the nitrate plot, and smaller, but relatively equal, yields for the ammonium sulphate and dried blood plots.

A Critical Comparison of the Yields in the Four Oat Crops.

The analytical data pertaining to the two oat crops of the first rotation and those pertaining to the two oat crops of the second rotation, furnish an abundance of material that is at times rather difficult to interpret. Variations in yield from season to season were due to climatic conditions as well as to differences in manurial treatment, and it is not always possible to define the influence of each in the particular instances. With that much granted, however, it will be noted that the different systems of fertilization have introduced gradually-widening variations in the yields of the different series. Starting with a soil that was uniform in composition throughout the several series, and subjecting them to different methods of treatment from the manurial standpoint, it was to be expected that the nitrogen salts, adding no organic matter to the soil, would in the course of time lead to the formation of soils of rather different physical characteristics than those resulting from the continued application of organic manures. It was to be expected, further, that differences would become apparent between the series where the fresh manures were used and those where the leached manures were used, as well as in the series where these manures were used in combination with nitrate. It was to be expected, likewise, that the continued application of ammonium sulphate would result, in time, in an increased soil acidity, since, as is well known, the base portion of the salt is used by the crops in greater proportion than is its acid portion. These and other expectations, based on theoretical considerations, find support in the actual yields as compared in the following tables:

The Yield of Dry Matter in the Four Oat Crops.

Series.	Nitrogen Applied. gms.	1899. gms.	Nitrogen Applied. gms.	1900. gms.	Nitrogen Applied. gms.	1904. gms.	Nitrogen Applied. gms.	1905. gms.
1..........	....	54.1	....	83.1	....	36.3	....	46.0
2..........	....	60.5	....	110.3	....	71.3	....	69.0
3........	3.32	82.2	4.05	144.4	4.02	123.7	3.96	120.3
4........	5.25	198.9	3.98	218.0	4.05	158.0	4.03	167.0
5........	1.96	76.4	3.99	127.1	4.15	118.7	4.01	129.7
6........	4.52	116.0	4.04	193.6	5.55	150.3	4.03	150.7
7........	0.78	112.0	0.78	166.3	0.78	104.7	0.77	126.3
8........	1.55	142.8	1.55	194.9	1.55	120.0	1.55	162.0
9........	4.10	121.6	4.83	195.0	4.80	140.0	4.73	158.7
10........	4.87	161.1	5.60	222.4	5.57	155.7	5.51	185.3
11........	6.03	210.8	4.76	264.8	4.83	162.3	4.80	196.3
12........	6.80	200.0	5.53	263.5	5.60	160.3	5.58	194.0
13........	2.74	113.6	4.77	175.2	4.93	129.0	4.78	156.3
14........	3.51	152.0	5.54	198.5	5.70	147.0	5.56	177.0
15........	5.30	150.4	4.82	215.3	6.33	161.0	4.80	182.0
16........	6.07	172.0	5.59	233.9	7.10	162.0	5.58	196.3
17........	1.62	111.4	1.52	188.0	1.62	110.3	1.62	137.7
18........	1.55	106.6	1.49	178.8	1.55	97.0	1.57	102.3
19........	3.58	130.8	5.51	192.3	5.77	137.3	5.63	161.3
20........	3.51	118.3	5.48	189.1	5.70	132.3	5.58	154.3

The above tables show, respectively, the yields of dry matter and of the nitrogen applied in the different series in the seasons 1899, 1900, 1904 and 1905. An attempt was made to have equivalent quantities of manure applied from season to season in the same series. This was actually carried out in the series where nitrate, ammonium sulphate and dried blood were used alone. In the fresh and leached manure series, however, and in the series where the manures were used in combination, equivalent amounts were not always applied. This is particularly true of the season of 1899. It will be noted that the solid, fresh, applied in that year, contained 3.32 grams of nitrogen against 5.25 grams in the solid and liquid, fresh; that the solid, leached, contained 1.96 grams of nitrogen, as against 4.52 grams of nitrogen in the solid and liquid, leached. In the other seasons the amounts of nitrogen applied in the manures were fairly constant; about four grams in each soil. There is only one exception to be noted here—that in case of the solid and liquid leached of 1904, when 5.55 grams of nitrogen were applied instead of the customary application of about four grams. These facts cannot very well be disregarded in the comparative study of the yields for the four seasons, lest the results become, in some cases, entirely unintelligible.

In series 1, where nothing at all was applied, the yields, as was to be expected, showed a falling off. The yield of dry matter in 1899 was 54.1 grams; in 1900, 83.1 grams; in 1904, 36.3 grams, and in 1905, 46.0 grams. The seasons of 1899 and 1904 were not favorable to large yields of oats; the seasons 1900 and 1905 were, on the other hand, quite favorable. A comparison of the yields of the latter seasons is probably more representative of the changed soil conditions. and the difference between 83.1 grams and 46.0 grams, in the yield of dry matter, indicates a decided falling off in the crop-producing power of the soils in series 1. It has already been stated, in previous reports, that phosphoric acid has become the minimum factor of fertility in the soils of this series, and hence too much stress should not be laid on these yields in comparing them with those of the other series, where nitrogen is, as a rule, the minimum factor of fertility. In series 2, where an excess of the minerals was applied and where the yield of crop is determined by the supply of nitrogen, the dry matter weighed 60.5 grams in 1899, 110.3 grams in 1900, 71.3 grams in 1904, and 69.0 grams in 1905. The favorable season of 1900 showed almost a doubling of the yield over that of 1899. The yields of 1904 and 1905 show a distinct falling off as against that of 1900, and, what is more interesting, the yield of 1905 is somewhat smaller than that of 1904, notwithstanding the more favorable conditions for the growth of the oat crop in 1905. This would indicate that the diminishing supply of nitrogen in series 2 more than offset the more favorable seasonal conditions of 1905.

The yields in series 3 for the four seasons were 82.2 grams, 144.4 grams, 123.7 grams and 120.3 grams, respectively. The yield of 1899 is smaller than any of the others, rendered more so by the smaller amount of nitrogen supplied. The practically equivalent quantities of nitrogen applied in the other seasons show, none the less, a gradual decline in yield, the crop of 1904 being somewhat larger than that of 1905, in spite of the better growing conditions in the latter season. The yield in series 4 was, for the four seasons, 198.9 grams, 218.0 grams, 158.0 grams and 167.0 grams, respectively. Because of the comparatively large amount of nitrogen applied in 1899, the yield here is proportionately as well as absolutely greater than that in series 3. The yield in 1900 was very considerably larger than that in 1904, or that in 1905, while in the two

last-named seasons that of 1905 showed a higher yield, viz., 167.0 grams, as compared with 158.0 grams in 1904. The relations in the solid and liquid, fresh, are therefore different from those in the solid, fresh, for the two seasons.

The yields in series 5 were 76.4 grams, 127.1 grams, 118.7 grams and 129.7 grams, respectively. The yield in 1899 was smaller than it would have been had the equivalent quantity of nitrogen been applied. The yield in 1900 was relatively smaller in this series than it was in the others, and was actually less than the corresponding yield in 1905, the only exception in the entire series. The yield in 1904 was again smaller than that in 1905. The yields in series 6 were 116.0 grams, 193.6 grams, 150.3 grams and 150.7 grams, respectively. Here, again, the yield of 1900 is markedly greater than that of 1904 or that of 1905, while the latter two are practically identical. On the whole, the yields from the solid, fresh, are greater than those from the solid, leached, and the yields from the solid and liquid, fresh, are greater than those from the solid and liquid, leached.

The equivalent quantities of nitrogen applied in series 7 for the four seasons show interesting differences in yield. The corresponding weights of dry matter were 112.0 grams, 166.3 grams, 104.7 grams and 126.3 grams, respectively. The yield of 1899 was evidently influenced by the unfavorable season, as was already noted in connection with the yield from other series. The yield in 1900 was very considerably above that of 1904, and even of that of 1905. The higher yield of 1905, as compared with that of 1904, was influenced by the more thorough utilization of the nitrate nitrogen, an influence felt, also, in the series where the nitrate was used in combination with the manures. In series 8, where the double quantity of nitrate was applied, the yields were 142.8 grams, 194.9 grams, 120.0 grams and 162.0 grams, respectively. Here, again, the yield of 1899 was larger than that of 1904, smaller than that of 1905, and considerably smaller than that of 1900. The proportionate increase from the single to the double portion of nitrate was greatest in 1899, for reasons to be discussed later. The falling off in yield from 1900 to 1904 and 1905 was not as great, proportionately, in series 8 as it was in series 7. In the combinations of manure and nitrate in series 9, 10, 11, 12, 13, 14, 15 and 16, there was in all cases a greater yield in 1900 than there was in the corresponding series in 1904 and 1905. There was

also, without exception, a larger yield in 1905 than there was in the corresponding series in 1904. The greater yield of dry matter in any of these eight series was 264.8 grams in series 11, for the season of 1900; 196.3 grams in each of series 11 and 16 for the season of 1905, and 162.3 grams in series 11, for the season of 1904. In general, the yields of series 12 were somewhat smaller than those of series 11. The yields of the even series are, with that one exception, uniformly higher than those of the corresponding odd series, and the yields from the fresh manure combinations are greater than the yields from the leached manure combinations. On the whole there is a marked falling off in the yield from 1900 to 1904 and 1905, and a greater yield in 1905 over that of 1904.

Similar relations hold good in series 17, where ammonium sulphate was used as the source of nitrogen, and in series 18, where dried blood was used as the source of nitrogen. In each case the yield of 1899 was larger than that of 1904 and smaller than that of 1900. The yield of the latter season was in every case markedly larger than the corresponding yield of any other season. The yields on series 17 and 18 were also smaller than the corresponding yields on series 8, where the equivalent quantity of nitrate nitrogen was applied. A proportionately better showing was made by the ammonium sulphate and dried blood nitrogen in 1900 as compared with the corresponding yields of the other seasons.

In series 19 and 20, where the ammonium sulphate and dried blood, respectively, were used in combination with solid, leached, the yields were uniformly smaller than in the corresponding nitrate combinations of series 14. Also here, the differences were proportionately smaller in 1900 than they were in the other season. In general, the yields of 1900 were highest, and the yields of 1899 lowest in series 19 and 20, and the yields in series 19 greater in every case than the corresponding yields in series 20.

The Yield of Nitrogen in the Four Oat Crops.

Series.	1899. gms.	1900. gms.	1904. gms.	1905. gms.
1	0.789	1.108	0.510	0.675
2	0.831	1.152	0.805	0.747
3	1.106	1.589	1.414	1.356
4	2.938	2.370	2.005	1.874
5	0.996	1.447	1.365	1.400
6	1.455	2.043	1.947	1.675
7	1.422	1.797	1.257	1.412
8	1.901	2.335	1.579	1.939
9	1.505	2.116	1.889	1.893
10	2.260	2.719	2.226	2.474
11	3.635	3.124	2.386	2.562
12	4.022	3.623	2.565	2.842
13	1.413	1.987	1.773	1.879
14	2.064	2.496	2.140	2.335
15	1.978	2.347	2.154	2.312
16	2.596	3.297	2.352	2.717
17	1.645	2.198	1.387	1.670
18	1.457	1.929	1.192	1.150
19	1.829	2.288	1.930	2.161
20	1.650	2.204	1.872	1.867

The differences in the yields of dry matter for the four seasons under consideration were discussed thoroughly in the preceding pages. The deductions drawn apply as well to the yields of nitrogen as given in the above table. The yields of 1900 were higher throughout than the corresponding yields of any other season, with the single exception in the yield of series 12, in 1899. The yields of 1904 and 1905 do not always run parallel to the yields of dry matter in these seasons. In a number of instances the nitrogen yields of 1904 exceed those of 1905, namely, in series 2, 3, 4, 6, 18 and 20. The nitrogen yields in series 7 and 8 show greater differences in 1905 than they do in 1904, and greater differences in the yields of 17 and 18 are also apparent in 1905. The fresh manures yielded more nitrogen to the crops than did the leached manures, whether used alone or in combination. The nitrate and solid, leached, combination, in series 14, yielded more nitrogen than did the corresponding ammonium sulphate and dried blood combinations in series 19 and 20. The use of ten grams of nitrate with any manure resulted uniformly in a higher yield of nitrogen than that obtained from five grams of nitrate when used with the corresponding manure. The differences in yield between the combinations where five grams of nitrate were used and

the corresponding combinations where ten grams of nitrate were used, are greatest in 1899 and least in 1904. Considerable differences are found, also, in the crop of 1900, particularly that of series 15 and 16, and of series 9 and 10.

The Average Increase Over the Check Plot in the Four Oat Crops.

Series.	1899.	1900.	1904.	1905.
1	....	....	....	....
2	....	....	....	....
3	0.275	0.438	0.609	0.609
4	2.107	1.218	1.200	1.127
5	0.165	0.295	0.558	0.653
6	0.640	0.891	1.142	0.928
7	0.591	0.627	0.452	0.665
8	1.070	1.183	0.774	1.192
9	0.674	0.964	1.084	1.146
10	1.429	1.567	1.421	1.727
11	2.804	1.972	1.581	1.815
12	3.191	2.471	1.760	2.095
13	0.582	0.835	0.968	1.132
14	1.233	1.344	1.335	1.588
15	1.143	1.528	1.349	1.565
16	1.765	2.145	1.547	1.970
17	0.814	1.046	0.578	0.923
18	0.626	0.777	0.387	0.403
19	0.998	1.136	1.125	1.414
20	0.819	1.052	1.067	1.120

An attempt is made in the above table to differentiate between the yields of nitrogen due to the soil itself and to the yields derived from the nitrogenous materials applied. It is assumed that the yield in series 2, where no nitrogen is applied, is due to that derived from the soil itself, and that equivalent quantities of soil nitrogen are also rendered available in the other series. It has already been pointed out elsewhere that the soils of the different series may actually yield more or less available nitrogen, yet a certain degree of approximation is attained by considering the yields of soil nitrogen as equivalent in the several series. By subtracting the yield on series 2, a quantity of nitrogen is still left, which is assumed to be due to the particular nitrogenous material used. It should be remembered, at the same time, that the full effect of any application of combined nitrogen is not felt on soils already well provided with available nitrogen. The

fact that the increase in 1899 and in 1900 was not proportionately greater is due to the more abundant supply of soil nitrogen during these two seasons. It will be noted that the increase over the check plot in series 3 was only 0.275 grams in 1899 and 0.438 grams in 1900, whereas the corresponding increase in 1904 and 1905 was 0.609 grams and 0.609 grams, respectively. The increase in series 4 was 1.218 grams in 1900, 1.200 grams in 1904 and 1.127 grams in 1905. The differences here are not great in spite of the fact that the yields of dry matter and of nitrogen were so much higher in 1900 than in the other seasons. The increased yields in series 5, for 1900, 1904 and 1905 were 0.295 grams, 0.558 grams and 0.653 grams, respectively, showing a smaller increase in 1900 than in the other two seasons. The same is true of series 6, 9, 13 and 20, and partly, also, of a number of the other series. Series 7 shows an increase of 0.591 grams, 0.627 grams, 0.452 grams and 0.665 grams, respectively, for the four seasons; and series 8, 1.070 grams, 1.183 grams, 0.774 grams and 1.192 grams, respectively. It will be noted that the greatest increase, both in series 7 and 8, occurred in 1905—that is, at a time when the soil itself could not furnish as much available nitrogen as it did in the earlier seasons. There is no doubt, likewise, that the actual increase in 1899 and in 1900 was less than that represented by the corresponding figures. The latter were of necessity somewhat exaggerated because of the better utilization of the nitrogen derived from the soil itself, in series 7 and 8, than was possible in the check series 2. Hence it would be expected that with the depletion of the stores of available soil nitrogen the nitrate nitrogen would show a proportionately larger increase, provided that the season is not over wet. As to the utilization of the nitrate itself, it would seem that in the presence of other nitrogen sources the nitrate nitrogen is more apt to be protected from loss, thanks to its more rapid utilization by the vigorous plants.

Attention should also be called here to the comparatively large increase in 1900 from the ammonium sulphate, and even larger increase from the dried blood:

The Average Recoveries in the Four Oat Crops.

Series.	1899.	1900.	1904.	1905.
1	....	....	....	....
2	....	....	....	....
3	8.3	10.8	15.2	15.4
4	40.2	30.6	29.6	28.0
5	8.4	7.4	13.4	16.3
6	13.8	22.1	20.6	23.0
7	75.8	80.4	58.0	86.4
8	69.0	76.3	56.1	76.9
9	16.4	20.0	22.6	24.3
10	29.4	28.0	25.5	31.3
11	46.5	41.4	32.7	37.3
12	46.8	44.7	31.4	37.5
13	21.3	17.5	19.6	23.6
14	35.1	24.2	23.4	28.6
15	21.6	31.7	21.3	32.6
16	29.1	38.3	21.8	35.3
17	50.3	68.8	38.8	57.0
18	40.4	52.1	27.8	25.6
19	27.9	20.6	19.5	25.1
20	23.3	19.2	18.7	20.1

The proportionate amounts of nitrogen recovered from the various nitrogenous materials applied are given in the above table. It will be seen that in series 3 the recovery was 8.3 per cent., 10.8 per cent., 15.2 per cent. and 15.4 per cent., respectively, for the four seasons, a showing strongly in favor of the two oat crops in the second rotation. In series 4 the recoveries were 40.2 per cent., 30.6 per cent., 29.6 per cent. and 28.0 per cent., respectively. Excluding the first crop, we obtain three yields rather uniform in character and slightly higher than the others in the case of the crop of 1900. In the solid, leached, the recovery in the crops of the first rotation was decidedly lower than that in the crops of the second rotation; and to a more limited extent this is also true of the solid and liquid, leached. In series 7 the five grams of nitrate showed a recovery of 75.8 per cent. in 1899, of 80.4 per cent. in 1900, of 58.0 per cent. in 1904, and of 86.4 per cent. in 1905. The recovery in series 8 from the double quantity of nitrate was 69.0 per cent. in 1899, 76.3 per cent. in 1900, 56.1 per cent. in 1904, and 76.9 per cent. in 1905. In every case, therefore, the recovery from the single application of nitrate was higher than that from the corresponding double application. The lowest recovery occurred in 1904, and exerted an influence, un-

doubtedly, on the recoveries in the various nitrate combinations. The recoveries from the fresh manure combinations were, on the whole, greater in the first rotation than they were in the second rotation, and the recoveries from the leached manure were also greater in the first rotation. The recoveries from the solid, fresh, combinations alone were greatest in 1905, while the recoveries from the solid and liquid, fresh, combinations were greatest in 1899. The recoveries from the solid, leached, combinations were slightly greater in 1899 than they were in 1905, while the recoveries from the solid and liquid, leached, combinations, were greatest in 1900, and then in 1905, 1899 and 1904, in the order named. The recoveries from the ammonium sulphate were 50.3 per cent., 68.8 per cent., 38.8 per cent. and 57.0 per cent., respectively, for the four seasons. The recovery in 1900 was here distinctly higher than that in 1905, and was lowest, as in the case of the nitrate, in 1904. The recoveries from the dried blood were 40.4 per cent., 52.1 per cent., 27.8 per cent. and 25.6 per cent., respectively, for the four seasons. In this case the recovery was highest in 1900 and lowest in 1905. In the combinations of ammonium sulphate and solid, leached, the recoveries were 27.9 per cent., 20.6 per cent., 19.5 per cent. and 25.1 per cent., respectively—that is, highest in 1899 and lowest in 1904. Similarly, in the combinations of dried blood and solid, leached, the recovery was highest in 1899 and lowest in 1904. Compared with series 14, where the corresponding nitrate combination was applied, both series 19 and 20 showed considerably smaller recoveries. It should also be noted here that the corresponding recoveries in series 19 and 20 did not show great variations, whereas in series 17 and 18, where the ammonium sulphate and dried blood, respectively, were applied alone, the variations in favor of the former were quite considerable, particularly in 1905, when the recovery from series 17 was more than double that in series 18.

The Composition of the Four Residual Crops.

The composition of the residual crops may serve better than that of the first crops to demonstrate how the soil nitrogen itself is affected by the methods of soil treatment followed in the different series. The cylinder soils contained large amounts of nitrogen at the beginning of the experiment, and a part of this nitrogen, thanks to the thorough stirring and mixing of the soil, was readily available.

For this reason the proportion of soil nitrogen to that derived from the various nitrogenous materials applied was necessarily greater in the first rotation than it was in the second rotation. The continuous growing of exhaustive crops depleted the store of soil nitrogen, especially in the series where only nitrogenous materials were used that added little or nothing to the humus nitrogen, as was the case in series 7, 8, 17 and 18. In the series where the solid or leached manure was applied, only a portion of the manure nitrogen went to supply the needs of the immediate crop. The remainder, consisting of the less quickly available portions of the manure nitrogen, was so changed as to become a part of the humus nitrogen, and henceforth became available but slowly. In this manner the soil nitrogen was somewhat protected from rapid exhaustion, and, as may be seen from the composition of the residual crops, the manure series were still capable of furnishing considerable quantities of available nitrogen to the residual crops, when that supply had become practically exhausted in the nitrate, ammonium sulphate and dried blood series. This fact is well brought out in the following tables, showing the average yields of dry matter and of nitrogen in the residual crops:

The Average Yields of Dry Matter in the Four Residual Crops.

Series.	1899.	1900.	1904.	1905.
1	41.4	129.2	32.0	44.3
2	86.1	127.8	47.3	56.7
3	135.1	190.4	97.0	111.7
4	135.2	179.8	90.0	89.7
5	113.1	191.0	88.0	127.0
6	96.9	152.6	99.0	107.3
7	67.3	109.5	45.0	53.0
8	61.8	121.3	51.0	60.7
9	107.5	187.8	102.0	116.0
10	139.4	209.9	107.3	132.0
11	131.7	179.6	97.3	121.3
12	169.4	193.0	102.3	120.0
13	105.0	221.3	98.7	114.3
14	115.9	198.2	93.3	120.0
15	103.1	186.2	108.7	118.0
16	101.2	185.6	104.0	129.7
17	73.9	113.5	46.7	64.3
18	73.4	126.1	60.0	92.0
19	97.5	174.1	80.3	113.7
20	91.1	176.2	111.3	146.3

The yields of dry matter in series 1 are smaller throughout than the corresponding yields in series 2. There is one exception to be noted, however—that in the yields of 1900. The slighter increase in dry matter in series 1 over series 2 is not accompanied here, as may be seen from the following table, by a corresponding increase in nitrogen. It should also be added here that the yields in 1900, in the two series in question, were much greater than the corresponding yields of the other seasons. As was pointed out repeatedly, series 1 should not be included in the comparison, since the yields here are not determined by the supply of nitrogen; nevertheless, these yields are valuable as giving an indication of the general conditions favorable or unfavorable to crop production. They show clearly that the season of 1900 was quite favorable for plant growth; that the season of 1904 was rather unfavorable, and that the season of 1905, everything considered, was decidedly favorable for the crops grown. The average yield of dry matter in series 2 was 106.9 grams in the first rotation, and only 52.0 grams in the second rotation. The falling off in yield was due here entirely to the exhaustion of available nitrogen, since an abundance of potash and phosphoric acid was supplied to the soils. In series 3, also, the highest yield of dry matter was in 1900 and the lowest in 1904. The average yield in the first rotation was 1.627 grams and the average yield in the second rotation only 1.043, a falling off not proportionately as great as in the preceding series, but still very large. The same is true, in a general way, of series 4, 5 and 6. Comparing the fresh manure in series 3 and 4, we find that the solid and liquid portion yielded less residual nitrogen than the solid portion. The same applies, also, to the leached manures in series 5 and 6, respectively.

In series 7, where nitrate alone was applied, the decline in the residual yield of dry matter is quite marked from the first to the second rotation. The average in the former was 88.4 grams and in the latter 49.0 grams. In other words, the residual yields in series 7 were actually smaller than the corresponding yields in series 2. An explanation for this was already offered, in previous reports, as due to the more thorough utilization of the soil nitrogen by the preceding crop with the aid of the nitrate applied. In series 8, where the double quantity of nitrate was applied, there was apparently a slight residual effect, and the falling off in yield from the first to the second rotation was proportionately smaller. In series 17, where ammonium sulphate

was applied, the residual yield was greater in 1899 and in 1905 than was the corresponding yield in series 8, and it was smaller in 1900 than in 1904. The decline in yield from the first to the second rotation was also quite marked here, but somewhat less than the corresponding decline in series 8. It should be pointed out here, however, that the decline in yield in series 17 was largely influenced, not alone by the depletion of the store of available soil nitrogen, but by the increased acidity of the soils in this series. In series 18 the residual yield of dry matter was quite appreciable in amount. In all cases the residual yield in this series was greater than the corresponding yield in series 8. The decline here from the first to the second rotation was also much smaller than the corresponding decline in series 8.

In series 9, 10, 11, 12, 13, 14, 15 and 16, where the manures were used in combination with nitrate, the residual yields are also invariably highest in 1900, and in most cases lowest in 1904. The residual yields in the fresh manure series are, with one exception, greater in the even series, where ten grams of nitrate were used in combination, than they are in the corresponding odd series, where only five grams of nitrate were used in combination. In the solid, leached, combinations, the residual yields in series 14 were larger in 1899 and 1905, and smaller in 1900 and 1904, than the corresponding yields in series 13. In the solid and liquid, leached, combinations, the residual yields were larger in series 15, in 1899, 1900 and 1904, and smaller in 1905, than the corresponding yields in series 16. The decline in yield from the first to the second rotation was proportionately greater in series 9 than in series 12. This shows that both in the solid, fresh, and in the solid and liquid, fresh, combinations the decline in the residual yield was greater where ten grams of nitrate were applied than in the corresponding series, where only five grams of nitrate were applied. In the leached manure combinations these relations are reversed, with the smallest decline, in each case, where the double portion of nitrate was used. In series 19 and 20, where ammonium sulphate and dried blood, respectively, were used in combination with the solid, leached, we note a large decline in yield in the former series, and but a slight decline in the latter, from the first to the second rotation.

The Average Yield of Nitrogen in the Four Residual Crops.

Series.	1899. gms.	1900. gms.	1904. gms.	1905. gms.
1	1.000	0.858	0.413	0.504
2	1.052	0.794	0.444	0.530
3	1.582	1.157	0.849	0.946
4	1.558	1.114	0.734	0.744
5	1.398	1.158	0.753	1.060
6	1.269	0.991	0.824	0.932
7	0.878	0.731	0.439	0.488
8	0.854	0.774	0.472	0.548
9	1.487	1.177	0.853	1.035
10	1.661	1.223	0.952	1.187
11	1.598	1.114	0.876	1.035
12	1.834	1.118	0.869	1.059
13	1.199	1.243	0.832	0.958
14	1.292	1.172	0.789	1.044
15	1.296	1.143	0.912	1.018
16	1.347	1.097	0.843	1.104
17	0.948	0.748	0.409	0.593
18	0.961	0.834	0.522	0.783
19	1.245	1.147	0.729	1.011
20	1.352	1.193	0.926	1.287

An examination of the above table will show that the average yield of nitrogen in the residual crop was much smaller in the second rotation than it was in the first rotation. This is brought out more clearly in the subjoined tabulation, where the total yield of nitrogen in the residual crops of the first and second rotation, respectively, is given:

Total Yield of Residual Nitrogen.

Series.	First Rotation. gms.	Second Rotation. gms.	Decrease. Per cent.
1	1.858	0.917	50.6
2	1.846	0.974	47.2
3	2.739	1.795	34.5
4	2.672	1.478	44.7
5	2.556	1.813	29.1
6	2.260	1.756	22.3
7	1.609	0.927	42.4
8	1.628	1.020	37.3
9	2.664	1.888	29.1
10	2.884	2.139	25.8
11	2.712	1.911	29.5
12	3.012	1.928	35.9
13	2.442	1.790	26.7
14	2.464	1.833	25.6
15	2.439	1.930	20.9
16	2.444	1.947	25.5
17	1.696	1.002	40.9
18	1.795	1.305	27.3
19	2.392	1.740	27.3
20	2.545	2.213	13.0

We note here, again, that the crop-producing power of the cylinder soils, in so far as the residual effects are concerned, had decreased to a remarkable extent even in the series where applications of manure are made annually. The greatest decrease, as was to be expected, occurred in series 1 and 2, where no nitrogen was added. An exceptionally large decrease in yield occurred, also, in series 4, 7, 8 and 17. As to the three latter series, the great falling off in yield from the first to the second rotation may be easily understood. These nitrogen salts returned the greatest part of their nitrogen in the first crop, and helped the latter to deplete the store of available nitrogen in the soil, thus leaving but little for the residual crop. In the case of series 4, however, the result is not as easily apparent. Nevertheless, it would seem that the large proportion of the easily-nitrifiable nitrogen compounds in the liquid manure acted, in part, like the nitrates in series 7 and 8. The leached manures showed a smaller decrease than the fresh manures. The solid and liquid portion of the leached manure showed a smaller decrease than the corresponding solid, leached, portion. The decrease in series 7 was greater than that in series 8, and also greater than that in series 17 and 19. The de-

crease in yield in the various combinations was greatest in series 12 and smallest in series 15. The fresh manure combinations showed a larger decrease than did the leached manure combinations. The solid, leached, and nitrate showed a smaller decrease than did the solid, leached, and ammonium sulphate, and a larger decrease than did the solid, leached, and dried blood.

The Average Increase Over the Check Plots in the Four Residual Crops.

Series.	1899.	1900.	1904.	1905.
1	....	....	....	....
2	....	....	....	....
3	0.530	0.363	0.405	0.416
4	0.506	0.320	0.290	0.214
5	0.346	0.364	0.309	0.530
6	0.217	0.197	0.380	0.402
7	....	0.091	....	....
8	....	0.049	....	....
9	0.435	0.383	0.409	0.505
10	0.609	0.429	0.508	0.657
11	0.542	0.320	0.432	0.505
12	0.782	0.384	0.425	0.529
13	0.148	0.449	0.388	0.428
14	0.240	0.378	0.345	0.514
15	0.244	0.349	0.468	0.488
16	0.295	0.303	0.399	0.574
17	....	0.062	....	....
18	....	0.040	0.078	0.253
19	0.193	0.353	0.285	0.481
20	0.300	0.399	0.482	0.757

While the total yields of nitrogen in the residual crops were greater in the first rotation, the yields of nitrogen over and above that in the check plots were greater in the second rotation, as is indicated in the above table. Apparently, the manure residues yielded more nitrogen to the crops in the second rotation than they did in the first rotation. The residual yield in series 3 is greater throughout than the corresponding yield in series 4, while the residual yield in series 6 is, with one exception, greater in every case than the corresponding yield in series 5. There was no definite increase over the check plot in series 7 and 8, with the exception of 1900, when the increase was quite slight. The same applies, also, to series 17 and 18. The increase in series 10 was greater than that in series 9, and the increase

in series 12 greater than that in series 11. The increase in series 14 was, on the whole, greater than that in series 13, and the increase in series 16 was, on the whole, scarcely greater than that in series 15. The increase from the fresh manure combinations was greater than that from the leached manure combinations. The increase in 1905 was almost invariably greater than the corresponding increase in 1904, while the increase in 1899 was greater than that in 1900 in series 3, 4, 6, 9, 10, 11 and 12, and smaller in series 5, 13, 14, 15, 16, 19 and 20. The increase from the solid, leached, and nitrate in series 14 was greater than that from the solid, leached, and ammonium sulphate in series 19, and smaller than that from the solid, leached, and dried blood in series 20.

The Avarage Recovery in the Four Residual Crops.

Series.	1899. Per cent.	1900. Per cent.	1904. Per cent.	1905. Per cent.
1	....	....	....	....
2	....	....	....	....
3	17.5	10.0	11.9	12.2
4	15.9	11.7	10.2	7.3
5	19.2	9.9	8.7	15.8
6	5.5	6.2	8.6	13.0
7	....	....	....	....
8	....	....	....	....
9	12.7	9.9	10.4	14.1
10	17.8	10.8	12.3	17.4
11	16.8	11.6	13.4	17.0
12	21.8	12.9	11.1	15.2
13	6.8	11.4	9.8	11.7
14	10.6	9.0	7.9	13.0
15	5.9	10.7	9.4	15.1
16	6.9	8.9	7.2	15.9
17	....	....	....	....
18	....	5.5	6.8	21.5
19	7.5	8.1	6.1	11.4
20	11.1	9.0	10.4	17.0

The recovery from the residual nitrogen was greatest in series 3, in 1899, and smallest in 1900. The same is true of series 10. Series 4 showed, on the whole, a smaller recovery than series 3, and series 6 showed a smaller recovery than series 5. The greatest variation in the recoveries from the former two series was in 1905, when the residual recovery in series 3 was 12.2 per cent., and in series 4 only

7.3 per cent. The greatest variation in the latter two series occurred in 1899, when the recoveries were 19.2 per cent. and 5.5 per cent., respectively, in series 5 and 6. The residual recoveries in series 10 were greater than those in series 9, the greatest variation in the recoveries from these two occurring in 1899. The recoveries in series 12 were greater than those in series 11 in the second rotation. The recoveries in series 14 were smaller than those in series 13, in 1900 and 1904, and larger than those in series 13, in 1899 and 1905. The same is true, also, of series 16 and 15, respectively. The recoveries from the fresh manure combinations were greater than those from the leached manure combinations. The recoveries from the solid, fresh, combinations were, on the whole, smaller than those from the solid, leached, combinations in 1899, 1900 and 1904, and smaller in 1905. The recoveries in series 14 were greater throughout than the corresponding recoveries in series 19, but smaller than the corresponding recoveries in series 20. This would indicate that the use of dried blood with the solid, leached, made possible a greater residual yield than was obtained from the corresponding nitrate and ammonium sulphate combinations.

The Average Yields in the Combined Crops for the Four Seasons.

The data presented in the following tables show that there was a falling off in the total yields of dry matter and of nitrogen from the first to the second rotation. While there is no doubt that this reduction is due, in part, at least, to the diminished humus and nitrogen content of the cylinder soils, it is difficult to determine more or less accurately the actual reduction in the fertility of the various soils. The averages, representing four crops in each rotation, were primarily influenced by the supply of plant-food in this case of available nitrogen. At the same time, the utilization of this plant-food by the plants, and its movement in the soil and subsoil, depended largely, also, on the seasonal conditions. Hence, whatever the analytical evidence, it would hardly be justifiable to regard the indicated falling off in yield from the first to the second rotation as an actual decrease in the crop-producing power of these soils. A greater number of seasons and a larger number of crops would be required than those under consideration, in order that the point in question be determined decisively and clearly. It would be safe, therefore, to bear this reser-

vation in mind when comparisons are made of the yields in the different soils. It should be remembered that where there is a falling off at all the decrease would be proportionately larger in those soils where the yields are greatest, since the production of plant-substance is more easily reduced after a certain degree of development has been reached.

The Average Yields of Dry Matter in the Combined Crops.

Series.	1899.	1900.	1904.	1905.
1	95.0	212.3	68.3	90.3
2	146.6	238.1	118.6	125.7
3	217.3	334.8	220.7	232.0
4	334.1	397.8	248.0	256.7
5	189.5	318.2	206.7	256.7
6	212.9	346.2	249.3	258.0
7	179.3	275.8	149.7	179.3
8	204.6	316.2	171.0	222.7
9	229.1	382.8	242.0	274.7
10	300.5	432.3	263.0	317.3
11	342.5	444.4	259.6	317.6
12	362.4	456.5	262.6	314.0
13	218.6	396.5	227.7	270.6
14	267.9	396.7	240.3	297.0
15	253.5	401.5	269.7	300.0
16	273.2	419.5	266.0	326.0
17	185.3	301.5	157.0	202.0
18	180.0	304.9	157.0	194.3
19	228.3	366.4	217.6	275.0
20	209.4	365.3	243.6	300.6

It will be noted in the above table that the total yield of dry matter in 1900 was far above that of any other season. This holds good of all the series, without exception, and is particularly striking in series 1 and 2. The extremely favorable seasonal conditions of 1900 were undoubtedly responsible for the exceptionally large yields. None the less, the season of 1905 was also very favorable for the growth of the crops in question, even though the yields were not as large as in 1900, and it may be suspected here that the lower yields of 1905, as compared with those of 1900, were due to the decreased crop-producing power of the cylinder soils. The yields in series 2 supply some definite information in this respect. It will be noted that the season of 1899 was not favorable for large yields of oats; nevertheless, there was more dry matter produced in that year, in series 2, than there was produced in 1905, notwithstanding the fact that the

latter was a good season for oats. Higher yields of dry matter were also obtained in 1899 in series 11 and 12.

It is easily apparent that the yields in 1900 were generally higher than those in 1899, and the yields in 1905 higher than those in 1904. A more detailed examination will show that the yields in series 3 are higher throughout than the corresponding yields in series 4, and that the yields in series 5 are higher throughout than the corresponding yields in series 6. It will also be observed that the differences in the yields between series 3 and 4 are greater in the first rotation *than they are in the second rotation.* Also, in series 5 and 6 the differences are, on the whole, greater in the first rotation; the latter will become more apparent when due allowances are made for the proportionately greater amount of nitrogen applied in 1904 in series 6. The total yields of dry matter in series 3 and 4 were greater than those in series 5 and 6, in 1899, 1900 and 1904, but smaller in 1905. The yields in series 7 were smaller than those in series 8, the differences between the two being greatest in 1900 and 1905. It is interesting to note here that the yields in series 7 were equal in 1899 and 1905, while in series 8 the yields of 1905 were appreciably larger than those of 1899. The differences in the yields between series 9 and 10 are larger than those between series 11 and 12, showing that the double portion of nitrate encourages the utilization of the nitrogen in the solid and liquid, fresh. Comparing series 9 and 11 and series 10 and 12, respectively, we find that the five grams of nitrate and the solid, fresh, gave higher yields than the five grams of nitrate and the solid and liquid, fresh. On the other hand, a corresponding increase in series 12 over series 10 is only apparent in the first rotation but *not in the second rotation. The yields in series 14 were greater than* those in series 13, and the yields in series 16 greater than those in series 15. The yields in series 15 were larger than those in series 13, and the yields in series 16 were larger than those in series 14. The other relations in the yields are brought out more clearly in the following table.

The Total Average Yields of Nitrogen in Each Rotation.

Series.	First Rotation. gms.	Second Rotation. gms.	Decrease. Per cent.
1	3.755	2.102	44.0
2	3.829	2.526	34.0
3	5.434	4.565	16.0
4	7.980	5.357	32.9
5	4.999	4.576	8.5
6	5.758	5.378	6.6
7	4.828	3.596	25.5
8	5.864	4.539	22.6
9	6.285	5.670	9.8
10	7.863	6.840	13.0
11	9.471	6.859	27.5
12	10.657	7.334	31.2
13	5.842	5.441	7.0
14	7.024	6.308	10.2
15	6.764	6.396	5.4
16	8.337	7.016	15.8
17	5.539	4.055	26.7
18	5.181	3.646	29.5
19	6.509	5.831	12.0
20	6.399	5.953	7.0

The yields of nitrogen in the above table show better than the corresponding yields of dry matter the relation of the different cylinder soils to one another. The yields of nitrogen in the first rotation were very much higher than the corresponding yields in the second rotation in series 2. Also, in the yields of nitrogen there was a greater return from series 4 as against series 3, and a greater return from series 6 as against series 5. The differences between the leached manures are smaller than the differences between the fresh manures. Similar relations hold good in the various combinations of manure and nitrate. The yields of nitrogen in series 8, 17 and 18 show a decrease in the order named, showing that the sodium nitrate was a better source of nitrogen than the ammonium sulphate, and the latter a better source of nitrogen than the dried blood. When used in combination the same materials, in series 14, 19 and 20, respectively, show similar relations. The differences here are not as great, proportionately, as they are in series 8, 17 and 18, being particularly small between the ammonium sulphate and dried blood combinations, and in one instance, the season of 1904, the yield of nitrogen in series 20 was actually greater than that in series 19.

The total average yields of nitrogen for each rotation, as well as the decrease in yield, are given in the above table. An examination of

the figures presented there will show an actual decrease throughout the entire series, as well as the relations between the different series as affected by the unequal decrease.

The decrease in yield from the first to the second rotation is evidently affected by the method of treatment to which the different soils were subjected. The crop-producing power of series 1 was reduced by 44 per cent., and the diminution in this case was due to the exhaustion of the available phosphoric acid rather than the exhaustion of the nitrogen. In series 2 the decrease was really due to the loss of the available nitrogen, and possibly to less favorable climatic conditions, and amounted to 34.0 per cent. A comparison of the other figures will show that this decrease was greater than that in any of the other series where phosphoric acid and potash were supplied. Theoretical expectations and practical results agree here fully, for the soils to which no nitrogen compounds were applied could not but show a greater proportionate reduction in their crop-producing power. Similarly, it would be expected that in the series where nitrogen salts alone were applied the decrease would also be large, since these materials proved to possess scarcely any residual effect, and encouraged, moreover, a more thorough utilization of the soil nitrogen. The decrease in series 7, where the single quantity of nitrate was applied, was greater than that in series 8, where the double portion was applied. It would seem, therefore, that the larger quantity of nitrate, by encouraging a larger growth and greater yield of roots and stubble, protected better the soil humus and soil nitrogen. The decrease in series 17 and 18, respectively, was greater than that in series 8. In the case of series 17 the decrease was due, not alone to the exhaustion of available nitrogen, but also to the increased acidity of the soil. In the case of series 18 the proportionately larger decrease is rather difficult to account for.

The decrease in series 3 was 16.0 per cent., and in series 4 it was 32.9 per cent. The large decrease in series 4, almost as large as that in the check series 2, cannot be readily interpreted, unless it is assumed that the readily oxidizable compounds in the liquid manure acted in part like the nitrates. It will be noted that the decrease is also proportionately large in series 11 and 12, where the solid and liquid, fresh, were used in combination. It remains true, at the same time, that the total yields of nitrogen in these series exceeded the yields in the other series, and hence the reduction, if due to climatic conditions, would fall more heavily on the series where the produc-

tion of plant substance is greatest. It will be observed, also, that the decrease in series 10, 12, 14 and 16 is greater in each case than the corresponding decrease in series 9, 11, 13 and 15. In other words, the double quantity of nitrate in the even series apparently hastened the exhaustion of the available soil nitrogen. The reservation as to seasonal influences should be made also here, however. The decrease in series 5 and 6 was comparatively small, showing that the insoluble forms of organic nitrogen applied in these series helped to maintain the fertility of the soil. The effect of these materials was felt, also, in the combinations with nitrate, as shown in series 13, 14, 15 and 16; and, likewise, in the combinations with ammonium sulphate and dried blood, as shown in series 19 and 20. In the latter series the decrease was smaller than that in series 19, notwithstanding the fact that the corresponding decrease in series 18 was greater than that in series 17.

The Average Increase Over the Check Plots in the Combined Crops.

Series.	1899. gms.	1900. gms.	1904. gms.	1905. gms.
1	....	....	....	....
2	....	....	....	....
3	0.805	0.801	1.014	1.025
4	2.613	1.538	1.490	1.341
5	0.511	0.659	0.867	1.183
6	0.857	1.088	1.522	1.330
7	0.417	0.618	0.447	0.623
8	0.872	1.232	0.803	1.210
9	1.109	1.347	1.493	1.651
10	2.038	1.996	1.929	2.384
11	3.346	2.292	2.013	2.320
12	3.973	2.855	2.185	2.624
13	0.730	1.284	1.356	1.560
14	1.473	1.722	1.680	2.102
15	1.387	1.877	1.817	2.053
16	2.060	2.448	1.946	2.544
17	0.710	1.108	0.634	0.986
18	0.535	0.817	0.465	0.656
19	1.191	1.489	1.410	1.895
20	1.119	1.451	1.549	1.877

The average increase over the check plot in the combined crops shows, also, the proportionately greater influence of the nitrogenous materials applied in the second rotation as against that in the first rotation. It was to be expected that the depleted stores of soil nitrogen would play a less important part in the second rotation. Irregu-

larities occur here, however, which need a word of explanation. It is evident that in series 3 the increase in yield was greater in the second rotation. In series 4, however, the yield was exceptionally large in 1899, and also large in 1900, showing a balance in favor of the first rotation. In series 5 and 6, where the leached manures were applied, the yields show uniformly a balance in favor of the second rotation. In series 7 the increase was slightly greater in the second rotation, while in series 8 it was somewhat smaller in the second rotation. In series 9 and 10, where the solid, fresh, was used in combination with nitrate, the increase was also greater in the second rotation. In series 11 and 12, on the contrary, where the corresponding combinations were made with the solid and liquid, fresh, the yields were exceptionally large in 1899, and also large in 1900, leaving a decided balance in favor of the first rotation. In the combinations of nitrate and leached manure, in series 13, 14, 15 and 16, the balance was also in favor of the second rotation. In series 17, the increase in yield was greater in the first rotation, a relation observable also in series 18. In series 19 and 20, where the ammonium sulphate and dried blood, respectively, of series 17 and 18, were used in combinations with the solid, leached, the increase was uniformly greater in the second rotation.

The Average Recovery Over the Check Plots in the Combined Crops.

Series.	1899. gms.	1900. gms.	1904. gms.	1905. gms.
1	....	....	....	....
2	....	....	....	....
3	24.3	19.8	25.2	25.9
4	49.8	38.6	36.8	33.3
5	26.1	16.5	20.9	29.5
6	18.6	26.9	27.4	33.0
7	53.6	72.2	57.3	81.0
8	56.3	75.0	51.8	78.0
9	27.1	27.9	31.1	34.9
10	41.8	35.7	34.6	43.2
11	55.5	48.1	41.7	48.0
12	58.4	51.6	39.0	47.0
13	26.7	26.9	27.5	32.6
14	41.9	31.1	29.5	37.8
15	26.2	38.9	28.7	42.8
16	33.9	43.8	27.4	45.6
17	43.9	65.8	33.5	60.9
18	34.5	54.8	30.0	41.7
19	33.2	27.0	24.4	33.7
20	31.9	26.5	27.2	33.7

The average recovery in series 3 was greater, somewhat, in the second rotation than it was in the first rotation. It was, on the whole, over 25 per cent.—that is, only one-quarter of the nitrogen contained in the solid, fresh, was returned in the crops, and that notwithstanding the repeated annual applications of manure the soil had not grown richer, but actually poorer, in nitrogen. The recovery from the solid and liquid, fresh, was greater than that from the solid fresh, yet even here the proportion recovered was much less than half of that applied. The recovery from the leached manures was decidedly larger in the second rotation than it was in the first. The solid and liquid, leached, showed a higher recovery than the solid, leached, and in 1904 it showed a greater recovery than did the solid, fresh. On the whole, the recoveries from the leached manures in the second rotation were not much smaller than those from the fresh manures. The recoveries from the nitrate were also greater in the second rotation, the differences being more marked in series 7. The recoveries in the solid, fresh, combinations were greater in the second rotation, while in the solid and liquid, fresh, combinations they were decidedly greater in the first rotation. In the leached manure combinations the differences were not as uniform, yet there was a slight balance in favor of the second rotation. In series 17 and 18 the recoveries were greater in the first rotation, while in series 19 and 20 the differences between the first and second rotation were not well marked.

The Calculated and Actual Recoveries in the Combined Crops of the Four Seasons.

1899.

	Series.	Nitrogen Recovered. Per cent.	Calculated Recovery. Per cent.	Nitrogen not Recovered. Per cent.
Solid manure, fresh........	3	24.3	....	....
Solid and liquid, fresh.....	4	49.8	....	....
Solid, leached	5	26.1	....	....
Solid and liquid, leached....	6	18.6	....	....
Sodium nitrate	7	53.6	....	....
Sodium nitrate	8	56.3	....	....
Ammonium sulphate	17	43.9	....	....
Dried blood	18	34.5	....	....
7 and 3 in................	9	27.1	29.83	9.3
8 and 3 in................	10	41.8	34.44	....
7 and 4 in................	11	55.5	50.27	....
8 and 4 in................	12	58.4	51.25	....
7 and 5 in................	13	26.7	34.01	21.7
8 and 5 in................	14	41.9	39.49	....
7 and 6 in................	15	26.2	23.76	....
8 and 6 in................	16	33.9	28.22	....
17 and 5 in...............	19	33.2	34.22	2.9
18 and 5 in...............	20	31.9	29.89	....

1900.

	Series.	Nitrogen Recovered. Per cent.	Calculated Recovery. Per cent.	Nitrogen not Recovered. Per cent.
Solid manure, fresh........	3	19.78	....	....
Solid and liquid, fresh......	4	38.61	....	....
Solid, leached	5	16.50	....	....
Solid and liquid, leached...	6	26.94	....	....
Sodium nitrate	7	72.22	....	....
Sodium nitrate	8	75.03	....	....
Ammonium sulphate	17	65.84	....	....
Dried blood	18	54.83	....	....
7 and 3 in................	9	27.89	28.24	1.24
8 and 3 in................	10	35.66	35.07	....
7 and 4 in................	11	48.14	44.14	....
8 and 4 in................	12	51.62	48.84	....
7 and 5 in................	13	26.90	25.60	....
8 and 5 in................	14	31.07	32.87	5.48
7 and 6 in................	15	38.95	34.25	....
8 and 6 in................	16	43.80	40.27	....
17 and 5 in...............	19	27.02	30.11	10.26
18 and 5 in...............	20	26.48	26.92	1.63

1904.

	Series.	Nitrogen Recovered. Per cent.	Calculated Recovery. Per cent.	Nitrogen not Recovered. Per cent.
Solid manure, fresh........	3	25.2	....	....
Solid and liquid, fresh.....	4	36.8	....	....
Solid, leached	5	20.9	....	....
Solid and liquid, leached...	6	27.4	....	....
Sodium nitrate	7	57.3	....	....
Sodium nitrate	8	51.8	....	....
Ammonium sulphate	17	33.5	....	....
Dried blood	18	30.0	....	....
7 and 3 in................	9	31.1	30.4	....
8 and 3 in................	10	34.6	32.6	....
7 and 4 in................	11	41.7	40.1	....
8 and 4 in................	12	39.0	40.9	7.0
7 and 5 in................	13	27.5	26.7	....
8 and 5 in................	14	29.5	29.3	....
7 and 6 in................	15	28.7	31.1	2.9
8 and 6 in................	16	27.4	32.7	5.3
17 and 5 in...............	19	24.4	24.4	....
18 and 5 in...............	20	27.2	23.4	....

1905.

	Series.	Nitrogen Recovered. Per cent.	Calculated Recovery. Per cent.	Nitrogen not Recovered. Per cent.
Solid manure, fresh........	3	25.9	....	....
Solid and liquid, fresh......	4	33.3	....	....
Solid, leached	5	29.5	....	....
Solid and liquid, leached...	6	33.0	....	....
Sodium nitrate	7	81.0	....	....
Sodium nitrate	8	78.0	....	....
Ammonium sulphate	17	60.9	....	....
Dried blood	18	41.7	....	....
7 and 3 in................	9	34.9	34.8	....
8 and 3 in................	10	43.2	40.6	....
7 and 4 in................	11	48.0	40.9	....
8 and 4 in................	12	47.0	45.7	....
7 and 5 in................	13	32.6	37.2	5.2
8 and 5 in................	14	37.8	43.0	5.2
7 and 6 in................	15	42.8	40.7	....
8 and 6 in................	16	45.6	45.4	....
17 and 5 in...............	19	33.7	38.5	4.9
18 and 5 in...............	20	33.7	32.9	....

The above tables, showing the actual and calculated recoveries for the four seasons, 1899, 1900, 1904 and 1905, prove quite conclusively that the use of nitrate and manure in combination did not reduce the yield, as compared with the sum of the yields due to those materials when they were used separately. There was, on the contrary, an increased yield in most instances when these materials were used together.

The Availability of the Different Nitrogenous Materials When that of the Nitrate is Taken as 100.

	1899.	1900.	1904.	1905.
Sodium nitrate	100.0	100.0	100.0	100.0
Ammonium sulphate ...	77.9	87.7	64.7	78.1
Dried blood	61.3	73.1	65.2	53.5
Solid manure, fresh....	43.1	26.4	48.6	33.2
Solid manure, leached..	46.4	22.0	40.3	42.7
Solid and liquid, fresh..	88.4	51.5	71.0	37.8
Solid and liquid, leached,	33.0	35.9	52.9	42.3

With sodium nitrate, in series 8, as the standard of comparison, the ammonium sulphate gave, proportionately, better returns in the first rotation than it did in the second. The same is also true of the

dried blood. The solid manures, both fresh and leached, made a proportionately better showing in the second rotation, as did also the solid and liquid, leached. The solid and liquid, fresh, on the other hand, gave better returns in the first rotation.

Plant Nutrition Studies.

During the past year the Station largely increased its plant nutrition studies by means of pot experiments.

General Plan of the Experiments.

The plan of the experiments contemplates a comprehensive study—*first*, of the needs for plant-food of certain rather well-defined soil types, when used for general farming; and *second*, the mineral requirements in the growth and development of legumes. The first type studied is the red shale, which occupies a larger proportionate area devoted to general farming than any other in the state. The soils of this area, while varying materially in respect to physical character and position in reference to the underlying shale rock, are quite uniform in their chemical composition, being well supplied with the chief mineral elements, phosphoric acid, potash and lime. The soils on this area, too, have been farmed for more than a century, and have thus suffered material changes in their original character. The study, therefore, included three subtypes or classes, viz.: (1) Those regarded as good; (2) those possessing medium fertility, and (3) those poor in quality. This distinction of three classes, made by farmers, would be fairly represented, under good conditions of culture, by the following range in yield of wheat per acre: (1) Twenty bushels; (2) fifteen bushels; (3) ten bushels.

Those of the first class have been well farmed, with a mixed rotation of corn, oats, wheat and hay, clover and timothy mixed, and well manured at least once in a four-year rotation. Those of the second, with the same general rotation, have been less carefully farmed, and have received only occasional dressings of manure. Those of the third are regarded as too poor to make it pay to farm them without an immediate expenditure of considerable sums for manure or fertilizers, and thus have been allowed to lie idle a part of the time.

The samples used in the experiment were taken from the farm of Mr. Charles H. Cook, of Belle Mead, Somerset county, New Jersey, of some 800 acres in area, and exhibiting in a marked degree the three classes desired.

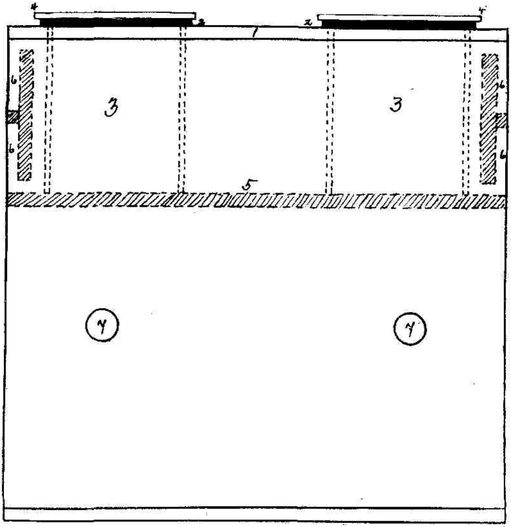
Methods of Study Used.

While these studies were carried out by means of the pot system, in which small amounts of soil are used under controlled conditions, the system used varied somewhat from that generally practiced in work of this character, where the pots are carried on trucks, which may be run to shelter during showers or rainy weather. The system adopted avoided the removal of the pots from the open air at any time, prevented an undue raising of the temperature, as the surface of the pots were not directly exposed to the atmosphere, and provided an easy means of weighing for controlling the amount of water added. The system may be described as follows, which, with the accompanying cuts, give a clear idea of the method used. In the first place, a framework was erected, three feet high, three feet wide, which was enclosed with matched boards, with openings on the top for insertion of the pots, of which a cross-section is shown in cut I. and a full view in cut II.

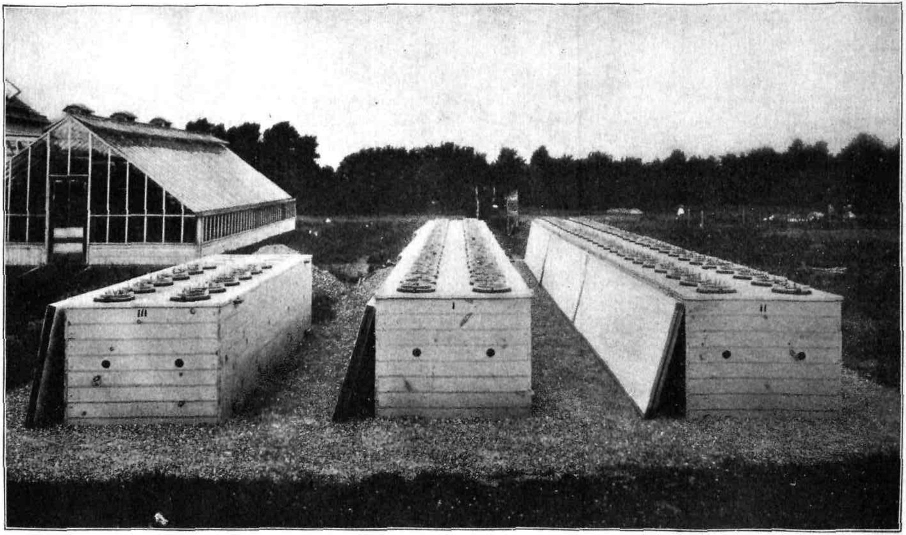
1. *Framework.*
2. *Iron ring for supporting jar.*
3. *Glass jars containing soil.*
4. *Flange on the glass jar.*
5. *Bottom support of jars.*
6. *Air space between outside and jars.*
7. *Openings in framework to permit circulation of air.*

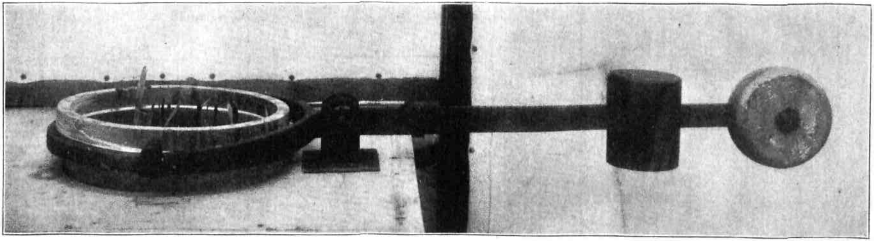
In order to protect the jars from heat radiated from the covering of the frame, boards were nailed to cleats on the inside, thus providing an air space between the jars and the outside covering.

An iron ring of the same diameter as the hole for the jar was placed on the top of the box for each jar, in order to facilitate weighing the jars without removing them from the box. This, together with the balance used, is shown in cut III. The jars were the ordinary museum jars, without tops, having an extended flange at the

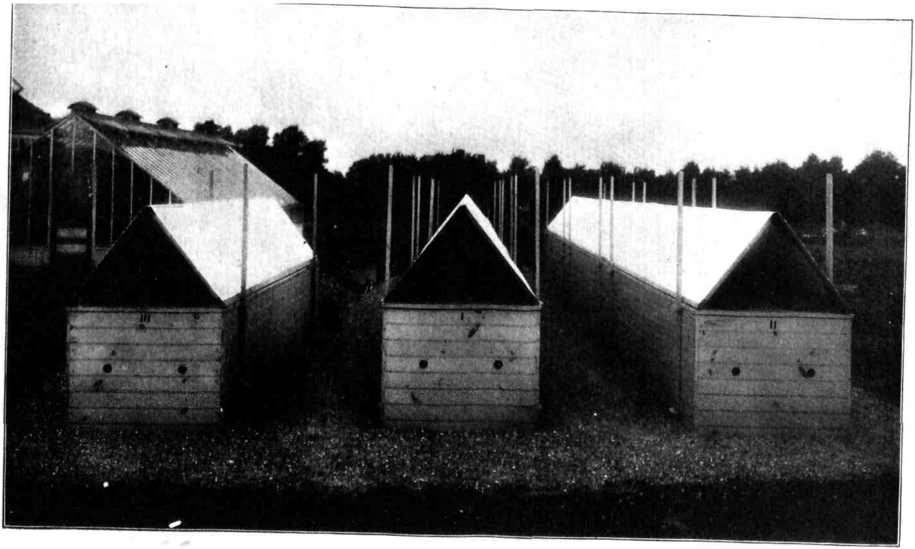


Cut I. Cross Section.





Cut III. Balance.



Cut IV. Roof Cover.

top, serving as a support for the jar, though the cross-pieces were carried through the frame under the boxes in order to relieve any sudden strain upon the flange. These jars were seven and one-eighth inches in diameter and ten inches deep. They were all tared by adding small quartz pebbles, and each contained exactly twenty pounds of soil. In order to protect the plants from high winds and from rain, a detachable roof was made by a framework, hinged in the middle and covered with duck. In order to provide for the growth of the plants, stakes were fastened to the sides of the frame, with holes bored in them at different distances. The roof could, by this device, be adjusted at different heights, and was held in place by means of iron staples. This was easily handled and thoroughly protected the plants. These are also shown in cut IV.

The general scheme of fertilization and cropping were as follows: Series 1 to 27, inclusive, experiment No. 1, were seeded with cow peas, and series 28 to 57, inclusive, experiment No. 2, were seeded with oats; series 58 to 60, inclusive, were seeded with a combination of oats and cow peas. Each series contained two jars, treated identically, and were, therefore, duplicates of each other.

The soils of each class were carefully prepared, first, by screening out all of the stones and the coarse material, thoroughly mixed, and a sample taken for analysis. Twenty pounds of soil were added to each jar. With the exception of series 9, 18 and 27, in both experiments, ten grams of lime were used, and the lime, phosphates and organic nitrogen thoroughly mixed with the soil in each jar. The soluble fertilizers were then applied in solution. In experiment No. 1, the soil improvement series, six seeds of the cow pea of the "Red Ripper" variety were planted in each jar, ten cc. of soil leachings, obtained by thoroughly stirring four to five pounds of soil from a field on which the proper bacteria were present with two to three litres of water, were used for watering the soils. Laboratory experiments showed that about forty parts of water were required to saturate the air-dry soil, which was added immediately after seeding, and the amount necessary to keep the soil at a 37 per cent. saturation was added from day to day, as needed—that is, the water was added in each jar until it was balanced at a given weight, which was easily accomplished by the system of weighing adopted. In the case of experiment 2, for the study of plant-food requirements, twenty seeds of oats were planted, and the water applied and the weighing

performed as in the case of the other series. In both cases the seed germinated well, though all the oat plants did not mature. In the case of the cow peas it was deemed best to remove two plants, leaving four in each jar. The plants in all cases made normal growth, though it is believed that it would have been better to have had a larger number of plants in the oat series. In the case of series 58 to 60, one-half the number of seeds of cow peas and oats were planted, and after germination one cow pea plant was removed.

Weights of the plants in their air-dry state are recorded, no examination yet having been made as to the variations in the total dry matter in the crop of oats or of the content of nitrogen in the cow pea series.

Cuts V., VI. and VII. are included, however, to show the differences due to different kinds of plant-food on the three classes of soil.

Pot Experiments.

To study the growth of leguminous plants upon the poor, medium and good soils of the sandstone (red shale) type.

Lines of Study.

1. The effect of an abundance of phosphoric acid.
2. " " " " " " potash.
3. " " " small, medium and large amounts of potash (KCl), in the presence of an abundance of available phosphoric acid (superphosphate).
4. The effect of small, medium and large amounts of phosphoric acid (superphosphate), in the presence of an abundance of potash (KCl).

Plan of Experiment.

1. Poor soil. Taken from the land of Charles Howell Cook, Belle Mead, N. J.
2. *Medium soil.*
3. Good soil.

Cut V. Poor Soil.

Number of Pots and Treatment.

Weight of Soil in Pots—Twenty Pounds.

Series I. (Two pots in each series.)	Phosphoric Acid. gms.	Potash. gms.	Yield in Grams.	
Poor Soil.				
1a, 1b	....	....	1a, 28	1b, 32
2a, 2b	2.00	....	2a, 44	2b, 42
3a, 3b	....	1.00	3a, 28	3b, 33
4a, 4b	2.00	0.25	4a, 44	4b, 43
5a, 5b	2.00	0.50	5a, 44	5b, 42
6a, 6b	2.00	1.00	6a, 43	6b, 42
7a, 7b	0.50	1.00	7a, 39	7b, 36
8a, 8b	1.00	1.00	8a, 44	8b, 35
*9a, 9b	2.00	1.00	9a, 33	9b, 29
Medium Soil.				
10a, 10b	....	....	10a, 44	10b, 48
11a, 11b	2.00	....	11a, 38	11b, 45
12a, 12b	....	1.00	12a, 48	12b, 49
13a, 13b	2.00	0.25	13a, 49	13b, 48
14a, 14b	2.00	0.50	14a, 56	14b, 46
15a, 15b	2.00	1.00	15a, 52	15b, 46
16a, 16b	0.50	1.00	16a, 51	16b, 43
17a, 17b	1.00	1.00	17a, 57	17b, 45
*18a, 18b	2.00	1.00	18a, 57	18b, 51
Good Soil.				
19a, 19b	....	....	19a, 37	19b, 35
20a, 20b	2.00	....	20a, 48	20b, 40
21a, 21b	....	1.00	21a, 41	21b, 36
22a, 22b	2.00	0.25	22a, 49	22b, 43
23a, 23b	2.00	0.50	23a, 52	23b, 45
24a, 24b	2.00	1.00	24a, 48	24b, 44
25a, 25b	0.50	1.00	25a, 43	25b, 41
26a, 26b	1.00	1.00	26a, 41	26b, 40
*27a, 27b	2.00	1.00	27a, 30	27b, 39
†58a, 58b, Poor soil	2.00	0.75	58a, 12	58b, 11
†59a, 59b, Medium soil	2.00	0.75	59a, 11	59b, 12
†60a, 60b, Good soil	2.00	0.75	60a, 17	60b, 15

* No lime applied.
† Oats and cow peas together.

Pot Experiments.

To study the soils of the red sandstone formation (red shale) in respect to their need for constitutent plant-food elements, namely, nitrogen, phosphoric acid and potash, in the growth of cereals.

Lines of Study.

1. The effect of phosphoric acid (superphosphate) alone.
2. " " " potash (KCl) alone.
3. " " " the nitrogen as nitrate when used in the phosphoric acid or potash.
4. The effect of the mineral elements, phosphoric acid and potash, alone.
5. " " " nitrogen as nitrate, as ammonia, and as organic matter, in combination with minerals.

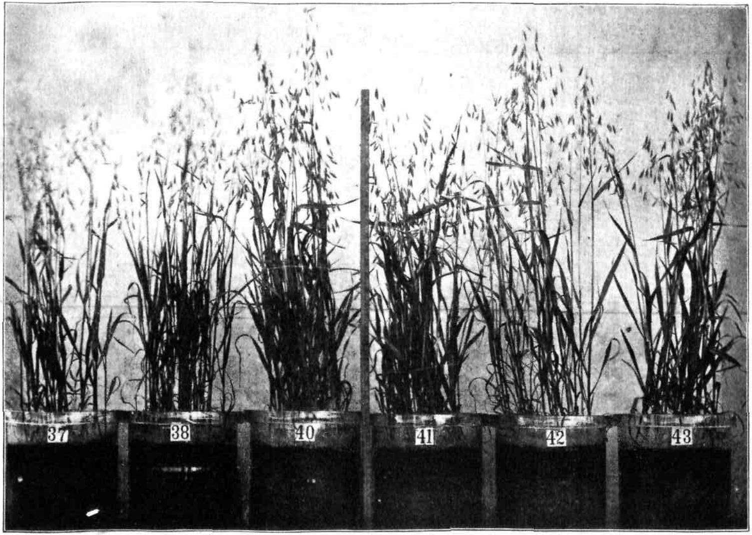
Plan of Experiment.

1. Poor soil. Taken from the farm of Charles Howell Cook, Belle Mead, N. J.
2. Medium soil.
3. Good soil.

Number of Pots and Treatment.

Poor Soil.

Series II. (Two pots in each series.)		gms.	Yield in Grams.	
28a, 28b,	Nothing	....	28a, 17	28b, 18
29a, 29b,	Phosphoric acid (superphosphate)	2.00	29a, 23	29b, 21
30a, 30b,	Potash	0.75	30a, 18	30b, 16
31a, 31b,	Phosphoric acid	2.00	31a, 31	31b, 29
	Nitrogen, as nitrate......	1.00		
32a, 32b,	Potash	0.75	32a, 21	32b, 16
	Nitrogen, as nitrate......	1.00		
33a, 33b,	Phosphoric acid	2.00	33a, 22	33b, 23
	Potash	0.75		
34a, 34b,	Phosphoric acid	2.00	34a, 36	34b, 30
	Potash	0.75		
	Nitrogen, as nitrate......	1.00		
35a, 35b,	Phosphoric acid	2.00	35a, 28	35b, 29
	Potash	0.75		
	Nitrogen, as sulphate of ammonia	0.76		
36a, 36b,	Phosphoric acid	2.00	36a, 29	36b, 28
	Potash	0.75		
	Nitrogen, as dried blood..	1.18		


37
38
40
41
42
43

Medium Soil.

		gms.	Yield in Grams.	
37a, 37b,	Nothing	....	37a, 18	37b, 17
38a, 38b,	Phosphoric acid (superphosphate)	2.00	38a, 24	38b, 26
39a, 39b,	Potash (KCl)	0.75	39a, 22	39b, 24
40a, 40b,	Phosphoric acid	2.00	40a, 32	40b, 32
	Nitrogen, as nitrate......	1.00		
41a, 41b,	Potash	0.75	41a, 26	41b, 27
	Nitrogen, as nitrate......	1.00		
42a, 42b,	Phosphoric acid	2.00	42a, 30	42b, 26
	Potash	0.75		
43a, 43b,	Phosphoric acid	2.00	43a, 30	43b, 30
	Potash	0.75		
	Nitrogen, as nitrate......	1.00		
44a, 44b,	Phosphoric acid	2.00	44a, 34	44b, 29
	Potash	0.75		
	Nitrogen, as sulphate of ammonia	0.76		
45a, 45b,	Phosphoric acid	2.00	45a, 30	45b, 29
	Potash	0.75		
	Nitrogen, as dried blood..	1.18		

Good Soil.

46a, 46b.	Nothing	....	46a, 20	46b, 21
47a, 47b,	Phosphoric acid (superphosphate)	2.00	47a, 24	47b, 25
48a, 48b,	Potash (KCl)...........	0.75	48a, 21	48b, 20
49a, 49b,	Phosphoric acid	2.00	49a, 30	49b, 30
	Nitrogen, as nitrate......	1.00		
50a, 50b,	Potash	0.75	50a, 21	50b, 15
	Nitrogen, as nitrate......	1.00		
51a, 51b,	Phosphoric acid	2.00	51a, 21	51b, 25
	Potash	0.75		
52a, 52b,	Phosphoric acid	2.00	52a, 28	52b, 25
	Potash	0.75		
	Nitrogen, as nitrate......	1.00		
53a, 53b,	Phosphoric acid	2.00	53a, 28	53b, 28
	Potash	0.75		
	Nitrogen, as sulphate of ammonia	0.76		

		gms.	Yield in Grams.	
54a, 54b,	Phosphoric acid	2.00	54a, 29	54b, 25
	Potash	0.75		
	Nitrogen, as dried blood..	1.18		
55a, 55b,	Poor soil. Nitrate of Soda,	1.00	55a, 18	55b, 17
56a, 56b,	Medium soil. " " "	1.00	56a, 24	56b, 22
57a, 57b,	Good soil. " " "	1.00	57a, 23	57b, 22
*58a, 58b,	Poor soil. Phosphoric acid,	2.00	58a, 15	58b, 18
	Potash	0.75		
*59a, 59b,	Medium soil. Phosphoric acid	2.00	59a, 17	59b, 18
	Potash	0.75		
*60a, 60b,	Good soil. Phosphoric acid	2.00	60a, 16	60b, 17
	Potash	0.75		

Field Experiments at Hammonton.

The experiments begun in Hammonton in 1904, to study methods of development of the light soils, as well as their adaptability for the growing of forage crops, were continued through the present year. As pointed out in the last report, an area of one acre was divided into plots of one-fifth acre each (experiment 1) and used for the purpose of studying the growth of soiling and forage crops, and a fertilizer rich in minerals applied at the rate of forty pounds per acre. These plots were seeded in the fall of 1904, the following crops being used:

Plot 1. Crimson Clover.
" 2. Rye and Sand Vetch.
" 3. Red Clover.
" 4. Wheat.
" 5. Rye.

These crops were harvested (with the exception of plot 5, which was plowed down) when in best condition for hay. The land was then immediately plowed, and seeded as follows:

Plot 1. Soy Beans.
" 2. Corn.
" 3. Millet.
" 4. Cow Peas.
" 5. Vetch and Oats.

* Oats and cow peas together.

Cut VII. Good Soil.

The yields contained are recorded in Table I. The plots were fertilized this year with thirty-two pounds per plot of acid phosphate and twenty pounds per plot of muriate of potash. Plots 2 and 3 received, in addition, fifteen pounds each of dried blood. The total area of one acre has therefore received, to date:

480 lbs. Acid Phosphate.
100 " Ground Bone.
260 " muriate of Potash.
150 " Dried Blood.
200 " Commercial Fertilizer.

Plots 1, 4 and 5 having received, in addition, sixteen pounds each of nitrate of soda, and plots 2 and 3, in addition, fifteen pounds each of dried blood.

The yields last year were, with the exception of plot 3, fairly good for soils that were naturally poor and sandy, which had received no yard manure. This year, with the exception of plot 5, two crops were *harvested on each area, and the yields were very satisfactory, indeed,* showing the improvement already gained by the application of fertilizers, and the seedings of clover, rye and wheat which followed this fall indicate a very material improvement in the crop-producing power of the soil. The seedings this fall were as follows, no additional fertilizer being applied:

Plot 1. Wheat and Vetch.
" 2. Crimson Clover.
" 3. Wheat.
" 4. Rye and Vetch.
" 5. *Crimson Clover.*

TABLE I.

Yield and Value of Crops in 1905.

Date of Harvesting.	First Crop.	Per Plot. lbs.	Per Acre. lbs.		
Plot 1. May 20	Crimson Clover Hay	470	2,350		
" 2. May 13	Rye and Vetch	700	3,500		
" 3. June 24	Red Clover Hay	600	3,000		
" 4. May 27	Wheat	670	3,350		
" 5.	Rye	...	....		
	Second Crop.			**Two Crops. Total. lbs.**	**Two Crops. Value.**
Plot 1. Aug. 4	Soy Beans	610	3,050	5,400	$43 20
" 2. Aug. 17	Corn	4,110	20,550	8,640	77 10
" 3. Aug. 30	Millet	940	4,700	7,700	61 60
" 4. Aug. 25	Cow Peas	530	2,650	6,000	48 00
" 5. July 14	Oats and Vetch	528	2,640	2,640	21 12

In experiment 2, planned to study the question of soil improvement, the rye seeded in the fall of 1904 made a fairly good growth and was plowed down early; one-half of the plots planted with white potatoes and the remainder with sweet potatoes. The yields were not good, though the quality of both white and sweet potatoes was excellent. The season accounted for the low yields, being very dry immediately after the rye was plowed under, hence a large number of the sweet potato plants died and the potato seed did not germinate well. Nevertheless, a very marked improvement is noted in the character of the soil. All of these plots were seeded with crimson clover, and it is planned to study the possibilities of growing cow pea seed as a field crop next year.

As stated in the report of 1904, the object of experiment 1 was to determine whether it was possible, on these light, sandy soils, to grow profitable forage crops, in succession, by the use of commercial fertilizer alone. Naturally, the first year, but one crop could be secured, though in the second, the present year, two crops were obtained on each plot with the exception of No. 5. The fertilizers applied this year were less than those applied the first year, as the object in the first year was to supply an abundance of the mineral elements, not only to provide for the immediate crop, but to permit of a sufficient amount remaining for the supply of succeeding crops. With the exception of a few weeks in May, when the weather was very dry, the season was favorable, and crops grew normally. It will be observed from the table that the crops, in all cases except the second crop on plot 2, were made into hay, and that the yields exceeded one ton of dried hay per acre, and in six cases either reached or exceeded one and one-half tons, being very satisfactory, indeed, and showing the advantage of keeping the soils occupied. The corn on plot 2 was cut in its green state and calculated back to air-dry condition. The value of these crops has been fixed at $16 per ton, this making a basis of comparison for the different plots. It will be observed, also, that the crops came in such a succession as to provide a continuous supply of green forage from early in May until September, and the yields show that one acre, on this basis, would provide a sufficient amount of roughage for one cow for one year, supplying it in the form of dry hay at the rate of sixteen and two-thirds pounds per day.

The value of the crops the second year, less the cost of fertilizer for that year, ranges for the different plots from $18.30 to $72.99; but inasmuch as the fertilizer the first year contributed to the value

of the crops in the second year, calculations have been made showing the value of the crops for the two years, less the cost of fertilizer for two years. This calculation is shown in Table II., and shows the value of crop, less fertilizer, ranging from $16.35, on plot 5, to $38.14, on plot 2. It is believed that these results could be obtained on a large area in that section of the State and would be of great value to the farmers, who now depend for feed upon foreign supplies, as an area of three to four acres would be sufficient to supply the needs of horses and cattle kept on farms in that section.

TABLE II.

Cost of Fertilizers and Value of Crops for Two Years.

	1904.		1905.					
	Cost of Fertilizer Per Acre.	Value of Crop.	Cost of Fertilizer Per Acre.	Value of Crop.	Total Cost of Fertilizer.	Total Value of Crops.	Value, Less Cost of Fertilizer.	Average Value of Crops.
Plot 1 ..	$13 52	$17 20	$2 80	$43 20	$16 32	$60 40	$44 08	$22 04
" 2 ..	11 92	15 20	4 11	77 10	16 03	92 31	76 27	38 14
" 3 ..	11 92	.....	4 11	61 60	16 03	61 60	45 47	22 73
" 4 ..	13 52	23 00	2 80	48 00	16 32	71 00	54 68	24 34
" 5 ..	13 52	27 90	2 80	21 12	16 32	49 02	32 70	16 35

REPORT OF THE SOIL CHEMIST AND BACTERIOLOGIST.

THE MEASURE OF SOIL FERTILITY FROM THE NITROGEN STANDPOINT.

Introduction.

The maximum yield of plant-substance is seldom attained on any soil area. Intensive methods of farm practice frequently insure a fair approximation to such maximum yields, yet even here the actual returns fall short of the possible returns, and the difference between the two is in many instances very considerable. To be sure, the maximum yield is not necessarily the most profitable yield. There is a point in the economy of crop production beyond which every additional increase possesses a slighter market value than its cost. But with this reservation it still remains true that our methods of soil treatment but too often fail to secure the best monetary returns.

It is well known that in so far as mere plant-food is concerned a maximum yield may be assured by an abundant supply of the various constituents. Under ordinary conditions of farming, however, it is but rarely that the supply of every plant-food constituent is ample enough for a maximum yield. Usually one or another of the plant-food constituents is present in limited amounts, and becomes thus the controlling factor in crop production. Nitrogen, phosphorus and potassium may each serve in this manner as setting a limit to the size of the harvests, it still being a disputed question as to which of the first two is more frequently the controlling factor. There are soils generally deficient in plant-food, but particularly deficient in one of its constituents, and there are soils, on the other hand, well supplied with all but one of the plant-food constituents. Evidently the problems of soil treatment are not identical in the two instances. In the poor soils the addition of the constituent present in the smallest proportion would increase the yield, but would not assure a maximum yield; while on the richer soils in question the abundant supply of the one limiting constituent would, everything else being favorable, assure a crop but little short of the maximum. Exact information in this

regard is of vital concern to practical husbandry, since without such information no effective and economical method of soil treatment can be devised or consistently pursued.

With the above facts in view, it is but proper to ask whether rational methods of soil treatment can be devised that would be applicable to soils of different origin and composition. Theoretical considerations might suggest the application of all of the plant-food constituents in quantities exceeding the requirements of the largest possible crop. Practically, however, a method of this nature would prove very wasteful. It would make possible very serious losses of plant-food, and particularly of nitrogen, and would be apt to introduce abnormalities in plant growth and undesirable qualities in the plant substance. Excessive applications, or at least very abundant applications of the so-called *mineral* constituents alone, would not be open to this objection to anything like the same extent, since, as is well known, potassic and phosphatic fertilizers are firmly held in the soil and suffer very slight losses from leaching. Furthermore, the cost of these fertilizers is much below that of high-grade nitrogenous materials, and their liberal use would not, therefore, call for as great an outlay. Hence we note that agricultural chemists, as well as progressive farmers, attempted, years ago, to develop a rational method of soil treatment and soil improvement as based on these facts. These attempts were largely crowned with success, especially on light, sandy soils, naturally deficient in plant-food and in humus. The possibilities in this direction were fully demonstrated by Schultz-Lupitz[1] in experiments extending over a period of more than forty years. He showed that the purchase of nitrogenous materials or the use of barnyard manures may be dispensed with entirely, and that the liberal use of lime, phosphorus and potassium, in conjunction with leguminous catch-crops, may be made the basis of a practical as well as highly profitable system of husbandry. His system provides for an excess of the mineral plant-food constituents and an abundance of nitrogen derived from atmospheric sources. The principal non-leguminous crops in his rotations are entirely dependent on the nitrogen thus derived from the air, and ultimately transformed into nitrates by the vigorous bacterial flora of the soil. There is no doubt that this system could be successfully employed on the vast areas of sand and sand loams in our Eastern States, where it is not already more or less in vogue. There is scarcely a doubt that large tracts of

[1] Zwischenfruchtbau auf leichtem Boden; Berlin, 1901.

land in South Jersey will in time gain an enhanced agricultural value in the application of this system. It will become possible, under such conditions of husbandry, to provide not merely for profitable returns from the land, but also for a more permanent fertility and a richer inheritance to the farmers of the future.

Under any given climatic conditions, and with any given mechanical composition of the soil, the system in question would make nitrogen the controlling factor of plant growth. Since, however, the nitrogen is to be derived from atmospheric sources through the symbiotic activities of leguminous plants and their tubercle bacteria, and, possibly, also, through the activities of non-symbiotic nitrogen-fixing bacteria; and since, furthermore, the combined nitrogen thus derived from atmospheric sources must first be simplified by the decay and nitrifying bacteria in the soil, it is quite evident that there is an intimate connection between the bacterial activities in the soil and the supply of available nitrogen to the succeeding non-leguminous crops. Similarly, in systems of farming where the nitrogen is not derived directly from the atmosphere, but from the soil humus, or from organic nitrogenous manures, the intensity of the bacterial activities in the soil will also be a measure of the extent to which the soil nitrogen may be made available to the growing crop in a given time. The various processes of nitrogen fixation, of decay, of nitrification and of denitrification, each play a certain role in the nitrogen feeding of the crop. It is conceivable that methods based on the intimate knowledge of the biological activities in the soil would find means to intensify the desirable processes of nitrogen fixation and nitrification; to suppress the objectionable denitrification, where it is at all apt to take place; to suppress, likewise, the too rapid oxidation of the organic matter, and those phases of decay that might lead to the liberation of elementary nitrogen. But, in order that such intelligent control may become possible, it is necessary to gain that more intimate knowledge of the soil bacteriological activities referred to above.

Systematic attempts to gain such "more intimate knowledge" have been made within the last three or four years, foremost among them being the studies of Remy[1] and of Hiltner and Stormer.[2] Remy was the first to suggest the quantitative differentiation of those definite bacterial processes that affect the soil nitrogen, and the first to compare, systematically, the nitrifying, denitrifying, ammonifying and

[1] Centr. f. Bact., etc., part II., vol. VIII. (1902), p. 657.

[2] Studien über die Bacterien-flora des Ackerbodens, etc., Berlin, 1903.

nitrogen-fixing power of various soils. It seemed to him that the measure of these processes, under standard conditions, might also be a measure of soil fertility as regarded from the nitrogen standpoint. His own results, and those of Lohnis,[1] Ehrenberg,[2] and Wohltmann, Fischer and Schneider,[3] would indicate that with proper precautions as to the experimental conditions, and with the intelligent interpretation of the results obtained, the method in question might really become an important factor in the interpretation of soil-fertility problems.[4] The experiments reported below are intended as a further contribution to the study of this method, and were carried out in connection with some red shale soils employed since 1898 in the cylinder experiments reported elsewhere in this volume.[5]

The Origin and History of the Soils.

The red shale loams, of which the cylinder soils are made up, were all of the same composition in 1898. Their differentiation began in that year, and has since been carried forward uninterruptedly. Nothing has been applied to the soils of series 1, and, thanks to their continuous and exhaustive cropping, their store of phosphoric acid, rather small at the beginning, has been very much depleted, and has now become the limiting factor in crop production. The soils of series 2 have been receiving annually abundant applications of acid phosphate and of muriate of potash, at the rate of 640 pounds and of 320 pounds per acre, respectively. No nitrogen has been applied to these soils, and the latter has therefore become the limiting factor. In the soils of series 3 the acid phosphate and muriate have been applied as in series 2, and they have received, besides, annual applications of fresh cow manure (solid excreta only) at the rate of about four grams of nitrogen per cylinder. The soils of series 4 received applications of acid phosphate and of muriate of potash as in series 2 and 3, and of fresh cow manure (solid and liquid excreta), also, at the rate of four grams of nitrogen per cylinder. The applications of manure were at the rate of about fifteen tons per acre.

[1] Centr. f. Bact., etc., part II., vol. XII. (1904), p. 261.

[2] Landwirtsch. Jahrb., XXXIII. (1904), p. 1.

[3] Journ. für Landwirtschaft, LII. (1904), p. 97.

[4] See also "Notes on the Progress of Soil Bacteriological Research," by Edward B. Voorhees and Jacob G. Lipman, in the Report of the Office of Experiment Stations, U. S. Dept. of Agriculture, for 1905.

[5] Edward B. Voorhees, "Investigations Relative to the Use of Nitrogenous Materials."

Two crops were harvested from each soil in 1905. The manures and fertilizers were applied in April, directly before the seeding of the oats. The residual crop, which was corn, received no further application of manure or fertilizers. The yields in the first and second crops, respectively, were as follows:

Oats, 1905.

Series.	Dry Matter. gms.	Nitrogen. gms.
1	46.0	0.675
2	69.0	0.747
3	120.3	1.356
4	167.0	1.874

Corn, 1905.

Series.	Dry Matter. gms.	Nitrogen. gms.
1	44.3	0.304
2	56.7	0.530
3	111.7	0.946
4	89.7	0.744

The differences in the yields of both dry matter and of nitrogen are quite distinct in the oat crop. The yields were progressively greater from series 1 to 4, showing that the acid phosphate and muriate of potash made possible a larger yield in series 2 as compared with that in series 1. Similarly, in series 4 the yield was greater than that in series 3, the difference being due to the greater amount of soluble and readily nitrifiable nitrogen added in the solid and liquid manure to the soils of series 4. In the residual crop the yield from series 2 was also greater than that from series 1, while the yield from series 4 was, on the other hand, smaller than that from series 3. The reverse relations between series 3 and 4 are due to the more rapid exhaustion of the manure nitrogen from the soils in the latter series. Because of the greater proportion of readily available nitrogen in the solid and liquid manure, the oat crop was greater in series 4 than it was in series 3. But the heavier yield left a smaller portion of available nitrogen in the soil, and hence the following crop was necessarily smaller, both in the yield of dry matter and of nitrogen, than that in series 3, where less nitrogen was taken out by the first crop and more of it left for the second crop.

Series 1.

Samples of soil were taken with a sterile spatula from each of the cylinder soils, 1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, 3c, 4a, 4b and 4c, and placed in stoppered sterile glass jars. The latter were then removed to the laboratory and ten-gram portions weighed off from each into 100-cc. portions of a sterile peptone solution containing 100 grams of Witte's peptone per liter of tap-water. The sterilization was

affected in the autoclave at about two atmospheres of pressure. Inoculation from each soil was made in duplicate and the duplicates kept for ten minutes in hot water at 80° C. It was intended thus to compare the ammonifying power of all of the decay bacteria with that of the spore-bearing organisms in each soil. After inoculation, and the pasteurization of the corresponding cultures, the culture flasks were placed in the dark. It should be added here that the samples were drawn off August 30th—that is, after the residual corn crop had made considerable growth.

After standing at room temperature for four days, the several cultures were diluted with distilled water, an excess of magnesium oxide was added to each, and after being placed on the distillation furnace were boiled for thirty minutes. The distillate was received in standard hydrochloric acid and titrated against standard ammonia, with cochineal as the indicator. The following amounts of nitrogen, as ammonia, were found in the different cultures:

Non-Pasteurized.

Soil Number.	Standard NH_4OH.	Nitrogen.	Av.	Soil Number.	Standard NH_4OH.	Nitrogen.	Av.
1a........	54.00 cc.	= 67.98 mg.		3a........	74.70 cc.	= 93.97 mg.	
1b........	51.10 "	= 64.28 "	64.89 mg.	3b........	78.00 "	= 98.12 "	9[illegible].11 mg.
1c........	49.65 "	= 62.46 "		3c........	76.50 "	= 96.24 "	
2a........	57.70 "	= 72.59 "		4a........	73.65 "	= 91.89 "	
2b........	59.50 "	= 74.85 "	74.73 "	4b........	76.40 "	= 96.11 "	93.11 mg.
2c........	61.00 "	= 76.74 "		4c........	78.00 "	= 91.83 "	

Pasteurized.

Soil Number.	Standard NH_4OH.	Nitrogen.	Av.	Soil Number.	Standard NH_4OH.	Nitrogen.	Av.
1a........	43.90 cc.	= 55.22 mg.		3a........	70.54 cc.	= 88.73 mg.	
1b........	41.60 "	= 52.33 "	53.25 mg.	3b........	72.45 "	= 91.14 "	90.97 mg.
1c........	41.50 "	= 52.21 "		3c........	73.95 "	= 93.03 "	
2a........	50.05 "	= 62.96 "		4a........	68.85 "	= 86.61 "	
2b........	47.85 "	= 60.19 "	64.36 "	4b........	70.05 "	= 88.12 "	87.99 mg.
2c........	55.60 "	= 69.94 "		4c........	70.95 "	= 89.25 "	

A comparison of the amounts of nitrogen set free as ammonia in the course of decay will show that the soils in series 1 set free less ammonia than those in series 2, and that the soils in series 4 set free less ammonia than did the soils in series 3. The same relations may also be observed in the pasteurized cultures, even though the yields here are uniformly smaller than those in the non-pasteurized cultures. It would seem that the relations existing between the spore-bearing organisms of the different soils are analogous to those between the entire bacterial floras concerned in the decay processes. Taking the yields of nitrogen in the corn crop at 100 in series 1, the corresponding yield in the other series would become:

The Relative Yields of Nitrogen.

Series 1	100
" 2	105
" 3	188
" 4	148

Similarly, in the yield of ammonia in the peptone solutions inoculated with the corresponding soils would become:

	Pasteurized.	Non-Pasteurized.
Series 1	100	100
" 2	121	115
" 3	171	148
" 4	165	143

These figures show that series 3 and 4 had a proportionately more vigorous spore-bearing flora than did series 1 and 2; otherwise, the relation in the pasteurized soils do not differ widely from those in the non-pasteurized soils. It should be stated here that one cc. of the standard ammonium hydroxide solution was equivalent to .001258 grams of nitrogen.

In order to determine whether the above differences would be retained on reinoculation into fresh media, new portions of the sterile peptone solution were inoculated, each with three loopfuls from the corresponding culture at the end of three days. When three days old, these reinoculations were boiled with magnesium oxide and the ammonia in the distillate determined in the customary manner, the following amounts of nitrogen were found:

Reinoculations.

Non-Pasteurized.

Soil Number.	Standard NH_4OH		Nitrogen.	Av.	Soil Number.	Standard NH_4OH		Nitrogen.	Av.
1a	4.20 cc.	=	15.12 mg.	15.44 mg.	3a	3.50 cc.	=	12.52 mg	10.97 mg.
1b	4.35 "	=	15.56 "		3b	2.30 "	=	8.22 "	
1c	4.40 "	=	15.74 "		3c	3.40 "	=	12.16 "	
2a	3.60 "	=	12.88 "	12.82 "	4a	2.70 "	=	9.66 "	10.43 "
2b	3.85 "	=	13.77 "		4b	2.50 "	=	8.94 "	
2c	3.30 "	=	11.80 "		4c	3.55 "	=	12.70 "	

Pasteurized.

Soil Number.	Standard NH_4OH		Nitrogen.	Av.	Soil Number.	Standard NH_4OH		Nitrogen.	Av.
1a	4.70 cc.	=	16.81 mg.	12.29 mg.	3a	2.90 cc.	=	10.37 mg.	10.73 mg.
1b	4.75 "	=	16.99 "		3b	3.35 "	=	11.98 "	
1c	3.65 "	=	13.06 "		3c	2.75 "	=	9.84 "	
2a	2.55 "	=	9.12 "	11.09 "	4a	2.65 "	=	9.48 "	11.44 "
2b	3.85 "	=	13.77 "		4b	3.00 "	=	10.81 "	
2c	2.90 "	=	10.37 "		4c	4.15 "	=	14.84 "	

1 cc. NH_4OH was equivalent here to .003577 gms. of nitrogen.

The differences in the original cultures were clearly not retained in the reinoculations, as the above figures show. The greatest proportion of ammonia nitrogen was split off here in series 1 and the least amount in series 4, the pasteurized and non-pasteurized reinoculations showing agreement in this respect. The smaller quantities of ammonia produced in the reinoculations may be easily explained, if it will be remembered that the peptone solution itself is not as well adapted to the vigorous growth of saprophytic bacteria as is a similar solution to which 10 per cent. of soil had been added, since the latter contains the small quantities of mineral matter necessary for the vigorous development of these organisms.

Series 2.

Fresh samples of the cylinder soils were drawn on October 4th, at the time of the harvesting of the corn. The samples were placed in sterile glass jars and taken to the laboratory, where five-gram portions were weighed off into fifty-cc. portions of a sterile 10 per cent. peptone solution. The soils used for inoculation were obtained from cylinders 1a, 2a, 3a, 4a, 5a, 6a, 7a, 8a, 11a, 12a, 17a and 18a. Ten inoculations were made from each, in order to permit a study of the gradual progress of ammonification. Ammonia determinations were to be made in one of each of the inoculations, at stated intervals. Determinations of total nitrogen were to be made at the end of four and of eight days, and sterile portions of the peptone solution were reserved for blank ammonia determinations, as was done, also, in series 1. The cultures were kept at room temperature, which ranged between 15° and 20° C. The yields of nitrogen and of dry matter in the corn crop were as follows:

Series.	Dry Matter. gms.	Nitrogen. gms.	Series.	Dry Matter. gms.	Nitrogen. gms.
1	44.3	0.504	7	53.0	0.488
2	56.7	0.530	8	60.7	0.548
3	111.7	0.946	11	121.3	1.085
4	89.7	0.744	12	120.0	1.059
5	127.0	1.060	17	64.3	0.593
6	107.3	0.932	18	92.0	0.783

The relations brought out above are expressive of the soil conditions at the beginning, rather than at the end of the growing period, and it is not at all unlikely that these relations had changed somewhat when the soil samples were drawn. With this fact in mind, it may be easier to interpret some of the results submitted below. It will be noted that the yield of nitrogen, and of dry matter, was greatest in series 5.

The yield of nitrogen was smaller in series 7 than it was in series 2, while the yield in series 8 was somewhat larger than that in series 2. The yield in series 17 was 0.593 grams and in series 18 it was 0.783 grams, differences that should find their analogy in the decay processes in the peptone solutions. As will be seen from the figures given below, these analogies do not always appear, and it would seem that the method has its limitations for soils of the same origin. At the same time, the consistent differences noted in series 1 are also brought out in this series in the case of the first four soils.

Series 2.

Ammonia Produced in 40 Hours.

Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.	Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.
1a......	0.80 cc.	2.83 mg.	6a......	1.15 cc.	4.07 mg.
1a......	1.00 "	3.54 "	7a......	1.00 "	3.54 "
2a......	1.00 "	3.54 "	8a......	0.90 "	3.18 "
2a......	0.85 "	3.00 "	11a......	1.00 "	3.54 "
3a......	1.25 "	4.42 "	12a......	0.85 "	3.00 "
3a......	1.15 "	4.07 "	17a......	0.65 "	2.30 "
4a......	1.10 "	3.89 "	18a......	0.60 "	2.12 "
5a......	1.20 "	4.24 "			

In 66 Hours.

Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.	Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.
1a......	2.30 cc.	8.13 mg.	6a......	2.75 cc.	9.72 mg.
1a......	2.20 "	7.78 "	7a......	2.35 "	8.31 "
2a......	2.35 "	8.31 "	8a......	2.40 "	8.49 "
2a......	2.35 "	8.31 "	11a......	2.40 "	8.49 "
3a......	2.85 "	10.08 "	12a......	2.55 "	9.01 "
3a......	2.90 "	10.25 "	17a......	1.60 "	5.66 "
4a......	3.10 "	10.96 "	18a......	2.10 "	7.42 "
5a......	2.70 "	9.55 "			

In 90 Hours.

Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.	Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.
1a......	3.45 cc.	12.20 mg.	6a......	4.45 cc.	15.73 mg.
1a......	3.40 "	12.02 "	7a......	3.90 "	13.79 "
2a......	3.70 "	13.08 "	8a......	3.70 "	13.08 "
2a......	3.80 "	13.44 "	11a......	3.80 "	13.44 "
3a......	5.20 "	18.37 "	12a......	4.60 "	16.26 "
3a......	5.30 "	18.72 "	17a......	2.85 "	10.08 "
4a......	4.70 "	16.62 "	18a......	3.25 "	11.49 "
5a......	4.15 "	15.03 "			

In 114 Hours.

Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.	Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.
1a......	4.55 cc.	16.09 mg.	6a......	7.35 cc.	25.99 mg.
1a......	4.65 "	16.44 "	7a......	6.00 "	21.22 "
2a......	5.85 "	20.68 "	8a......	6.00 "	21.22 "
2a......	5.95 "	21.04 "	11a......	5.70 "	20.15 "
3a......	7.45 "	26.34 "	12a......	7.00 "	24.75 "
3a......	7.55 "	26.70 "	17a......	5.55 "	19.62 "
4a......	6.95 "	24.57 "	18a......	6.15 "	21.75 "
5a......	6.35 "	22.45 "			

In 138 Hours.

Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.	Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.
1a......	5.20 cc.	18.39 mg.	7a......	6.55 cc.	23.16 mg.
2a......	6.10 "	21.57 "	8a......	6.60 "	23.34 "
3a......	8.60 "	30.41 "	11a......	6.85 "	24.22 "
4a......	7.75 "	27.40 "	12a......	7.55 "	26.70 "
5a......	8.30 "	29.35 "	17a......	4.75 "	16.70 "
6a......	8.25 "	29.17 "	18a......	6.10 "	21.57 "

In 164 Hours.

Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.	Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.
1a......	6.55 cc.	23.16 mg.	7a......	11.55 cc.	40.84 mg.
2a......	9.35 "	32.66 "	8a......	10.75 "	38.01 "
3a......	11.40 "	40.31 "	11a......	11.35 "	40.13 "
4a......	10.35 "	36.60 "	12a......	12.05 "	42.61 "
5a......	11.20 "	39.60 "	17a......	9.85 "	34.43 "
6a......	13.10 "	46.32 "	18a......	13.85 "	48.97 "

In 188 Hours.

Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.	Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.
1a......	9.45 cc.	27.30 mg.	7a......	13.60 cc.	39.29 mg.
2a......	12.65 "	36.54 "	8a......	13.50 "	39.00 "
3a......	14.65 "	42.32 "	11a......	13.55 "	39.14 "
4a......	14.50 "	41.89 "	12a......	15.10 "	43.62 "
5a......	15.20 "	43.91 "	17a......	11.25 "	32.50 "
6a......	15.85 "	45.79 "	18a......	13.75 "	39.72 "

In 212 Hours.

Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.	Soil Number.	Standard NH_4OH.	Ammonia Nitrogen Found.
1a......	10.70 cc.	30.91 mg.	7a......	14.70 cc.	42.46 mg.
2a......	13.85 "	40.01 "	8a......	14.35 "	41.46 "
3a......	15.35 "	44.35 "	11a......	15.55 "	44.92 "
4a......	16.20 "	46.80 "	12a......	14.60 "	42.18 "
5a......	16.70 "	48.24 "	17a......	13.05 "	37.70 "
6a......	17.40 "	50.27 "	18a......	13.85 "	40.01 "

Determinations of Total Nitrogen.

	In 96 Hours.		In 192 Hours.	
Blank......	20.20 cc.	71.59 mg.	....	....
Blank......	20.35 "	72.12 "	....	....
1a.........	22.10 "	78.32 "	26.70 cc.	77.13 mg.
2a.........	21.65 "	76.73 "	26.65 "	76.99 "
3a.........	21.95 "	76.79 "	27.00 "	78.00 "
4a.........	22.00 "	77.97 "	27.40 "	79.16 "
5a.........	22.30 "	79.03 "	27.25 "	78.72 "
6a.........	22.15 "	78.50 "	24.00 "	69.33 "
7a.........	22.05 "	78.04 "	27.10 "	78.29 "
8a.........	21.70 "	76.90 "	26.75 "	77.28 "
11a.........	22.45 "	79.56 "	27.25 "	78.72 "
12a.........	22.25 "	78.85 "	27.20 "	78.58 "
17a.........	22.05 "	78.04 "	27.20 "	78.58 "
18a.........	22.15 "	78.50 "	27.25 "	78.72 "

The distillation of sterile portions of peptone yielded, on the average, ammonia equivalent to .25 cc. of standard NH_4OH, or .89 mg. of nitrogen.

The amounts of ammonia found at the end of forty hours were not large, and did not show wide differences. The yields in series 1 and 2 were practically identical, and smaller than those in series 3. In the latter, the amounts of ammonia produced were greater than those in any other series with the exception of series 5. The yield

in series 6 was smaller than that in series 5, and the yield in series 4 smaller than that in series 3. The yield in series 8 was smaller than that in series 7, the yield in 12 smaller than that in 11, and the yield in series 18 somewhat smaller than that in series 17. The yields in the two last-named series were even smaller than those in series 1 and 2. On the whole, however, the differences were slight, not exceeding, in many instances, the limit of error.

At the end of sixty-six hours the differences were already more pronounced. The yields in series 2 were slightly, but distinctly, greater than those in series 1, the duplicates showing satisfactory agreement. The yields in series 3 exceeded those in 2, but were smaller than those in series 4. The yields in series 5 and 6 were practically the same, and smaller than those in 3 and 4. The yields in 7, 8 and 11 showed scarcely any differences, and were all lower than those in series 3, 4, 5 and 6. Series 17 and 18 were still behind the others, particularly series 17, where the yield was much smaller than that in series 1.

At the end of ninety hours the differences in the first four series became distinctly wider. There was an average yield of 12.11 mg. of ammonia nitrogen in series 1, of 13.26 mg. in series 2, of 18.54 mg. in 3, and of 16.62 mg. in 4. It will be noted that the duplicates in the first three series showed a very gratifying agreement, indicating thus that under standard conditions it would not be at all unreasonable to expect thoroughly concordant results. The relations here were changed somewhat, for series 3 already showed a decidedly greater yield than series 4. Series 6 still showed a greater yield than did series 5; series 1 a greater yield than series 11, and series 18 a greater yield than series 17. On the other hand, series 7 gave a greater yield than did series 8. Series 17 and 18 were still markedly behind any of the other series.

At the end of 114 hours the relations in the first four series remained unchanged, although the increase in the ammonia nitrogen produced was in all cases quite large. The relations between 5 and 6, 11 and 12 and 17 and 18, also remained the same. It should be noted, likewise, that the yields in series 17 and 18 were no longer smaller than those in series 1. The yields in series 7 and 8 were the same, and somewhat greater than those in series 2. Also, here the duplicates in series 1, 2 and 3 showed a very gratifying agreement.

At the end of 138 hours the same relations were still maintained in series 1, 2, 3 and 4. The relations between 11 and 12, and 17 and

18, were unchanged; 7 and 8 still gave practically the same yields, and series 5 gave a higher yield than did series 6. The yields in series 2 and 18 were identical, while series 17 seemed to have lost rather than gained ammonia. This apparent loss may have been due, however, to the retarded growth in this particular culture, as is indicated by the yields in the subsequent periods. The yield in series 3 still remained greater than that in any other series, and the yields in series 5 and 6 were still greater than those in series 11 and 12. The relations in series 1, 2, 3 and 4 were still unchanged at the end of 164 hours. The absolute gains were very considerable, as, for instance, in series 2 and 4, where there was a gain in each of more than eleven milligrams of ammonia nitrogen. Series 6 was here, again, ahead of series 5, with a yield of 46.32 mg. of nitrogen for the first time exceeding that in series 3. Series 7 showed a distinctly greater yield than did series 8; series 12 a greater yield than series 11, and series 18 a greater yield than series 17. The latter also forged ahead of series 2, with a yield of 34.43 mg., as against 32.66 mg. in series 2. The yield in series 18 is particularly noteworthy here, since it not only exceeded the yield in any of the other cultures, but more than doubled the yield of ammonia nitrogen in twenty-six hours. This result should be accepted, however, with a certain reservation, since, as was already noted, occasional cultures may for some unknown reason show very wide variations from other cultures of the same origin kept under the same conditions. We note here, likewise, that series 7 has given not only a greater yield than did series 2, but has actually exceeded that of series 3.

Again, at the end of 188 hours, the first four series show the same relations, although within narrower limits. Similarly, series 7 and 8, 11 and 12 and 17 and 18, maintain the same relations. Series 7 has again fallen behind series 3, as is true, also, of series 18. Series 17 yielded only 32.50 mg. of ammonia nitrogen, as against 34.43 mg. in the preceding period, and series 18 yielded 39.12 mg. as compared with 48.97 mg. in the preceding period. A similar reduction in yield apparently took place in series 6, 7 and 11.

In the final period of 212 hours there was still a gain of ammonia nitrogen in most cases. A change also occurred in the relations between series 3 and 4, since the latter gave, in this case, a higher yield of ammonia. On the other hand, series 5 and 6, series 7 and 8 and series 17 and 18, still maintained the same relations. Series 11 gave here a higher yield of ammonia nitrogen than did series 12,

thus reversing the relations observed in the other periods. The yields in series 2 and 18 were the same, as was noted in one other period, while the yield in series 17 was below that in series 2. The yields in series 7 and 8 were greater than that in series 2, but distinctly smaller than those in series 3 and 4, or those in series 11 and 12. The determinations of total nitrogen in parallel sterile portions of the peptone solutions show that there was present in each portion of the culture medium an average of 71.85 mg. of nitrogen. Hence, it is apparent that the proportion of nitrogen split off as ammonia in the course of 212 hours was quite large. The highest yield of ammonia nitrogen (that in series 6) was 50.27 mg., or almost 70 per cent. of that originally present in the solution. The amounts of ammonia nitrogen split off in the same period in series 1 was only 30.91 mg., or not quite 43 per cent. of that originally present in the solution. This shows clearly to what extent soils of the same origin may be differentiated bacteriologically by different methods of soil treatment.

It is interesting to note, in this connection, that the far-reaching transformation of the peptone nitrogen, as noted in the above experiments, did not, on the whole, involve any losses of nitrogen. The original nitrogen content of the peptone solution was augmented by that contained in the five grams of soil used for inoculation in each instance, and made the total nitrogen content of each culture about 77 to 79 mg. The analyses for total nitrogen, made at the end of 96 and 192 hours, respectively, show but slight differences, not much beyond the limit of error, in such comparatively large quantities of nitrogen. The results are the more gratifying since the soil used for inoculation was not weighed on the analytical balance, but on the torsion balance, and appreciable differences (not exceeding .2 mg. of nitrogen) were thus introduced. As stated above, the analyses made at the end of 96 and 192 hours, respectively, did not indicate any appreciable diminution of nitrogen. There was only one exception, that in series 6a, where the nitrogen content was apparently reduced from 78.50 mg. to 69.33 mg. In the other series the gains and losses nearly balance, and it is safe to assume, therefore, that under the conditions of the experiment there was neither a liberation of elementary nitrogen nor a volatilization of ammonia from the cultures. This is in accord with similar observations made by Ehrenberg,[1] although the analytical differences found by the latter are considerably larger.

[1] Centr. f. Bact., etc., part II., vol. XV., p. 154.

On the other hand, there are undoubtedly conditions where very considerable losses of elementary or combined nitrogen may occur in culture solutions free from nitrates. The writer's own experiments[1] prove clearly that the losses thus occasioned may be very marked. It is not at all unlikely that marked losses would have occurred also in the peptone solutions in question had they been allowed to stand for a longer period. Considerable importance is attached to this question, in so far as practical agriculture is concerned, for there is no doubt that in the transformations of the organic soil nitrogen there are conditions where large amounts of it are lost, either as free nitrogen, or, to a more limited extent, as ammonia. Under different conditions, on the contrary, the transformation of the humus nitrogen may proceed without loss. Hence it is of great importance to gain a more intimate knowledge of the various methods of soil treatment, whereby profitable crop-production would be accompanied by a minimum waste of soil nitrogen.

The Proportionate Yields of Ammonia Nitrogen in the Several Periods.

The data presented above show, unquestionably, certain essential agreements from day to day that assign to the method a possible value, for practical purposes, in the measure of soil fertility. A further attempt is made below to determine the period or periods at which the yields of ammonia are more nearly parallel to the actual yields of nitrogen in the corn crop. The yield in series 1 is taken in each case at 100, and the yields in the other series in proportion:

The Yield in the Corn Crop.			The Yield of Ammonia Nitrogen.							
Series.	Nitrogen.	Dry Matter.	40 Hours.	66 Hours.	90 Hours.	114 Hours.	138 Hours.	164 Hours.	188 Hours.	212 Hours.
1........	100	100	100	100	100	100	100	100	100	100
2........	105	128	103	105	109	128	117	141	134	130
3........	188	252	133	128	153	163	165	174	155	143
4........	148	203	122	138	137	151	149	158	153	153
5........	210	287	133	120	124	138	159	171	161	156
6........	185	242	128	122	130	160	159	200	168	163
7........	95	119	111	105	114	131	126	176	144	137
8........	109	157	100	107	108	131	127	164	143	134
11........	205	274	111	107	111	124	132	173	144	145
12........	210	271	94	113	134	152	145	185	160	136
17........	117	145	72	71	83	121	91	149	120	122
18........	155	208	67	93	95	134	117	211	145	130

[1] N. J. Stat. Rep., 1902, p. 183; ibid, 1903, p. 217.

There is a fairly-constant widening ratio up to 164 hours between the yield in the first series and that in the other series. After that this ratio grows distinctly narrower. When compared on the basis of nitrogen yields, the determinations at the end of 90 hours and 114 hours show a closer analogy to the nitrogen yields in the corn crop than do any of the other determinations. The method fails to show, however, the larger yields in series 5 and 6, as well as those in series 11 and 12. It should be remembered, at the same time, that this method deals only with the ammonification processes which represent merely a portion of the bacterial activities in the soil. The humus nitrogen is also affected by the process of nitrification, and probably, also, by denitrification and nitrogen-fixation. Hence, the bacterial processes of ammonification in the soil should not be expected to furnish complete information as to the availability of the organic nitrogen in the soil.

Series 3.

The above experiments demonstrate that there is a certain relation between the ammonifying power of some of the cylinder soils and their yield of nitrogen in the crop. The question naturally arose, in this connection, whether these differences were due to the bacteria themselves or to the combined influence of the soils and their corresponding bacteria. Since the soil bacteria are easily brought in suspension,[1] it was assumed that inoculation could be accomplished by adding to the medium a measured quantity of soil infusion obtained by shaking together soil and sterile water. Accordingly, 100-gram portions of the cylinder soils, drawn on October 26th, were shaken for several minutes with 200 cc. portions of sterile tap-water, and 10 cc. of the suspension, representing five grams of soil, were used for the inoculation of 50 cc. portions of a sterile peptone solution. For the sake of comparison, similar portions of peptone were inoculated with five-gram portions of soil. A peptone solution was also prepared containing the same quantity of peptone dissolved in tap-water, to which had been added .5 grams of K_2HPO_4, .2 grams of $MgSO_4$, and .02 grams of $CaCl_2$ per liter. This solution was made slightly alkaline to phenolphthaleine by the addition of sodium hydroxide. Also, this second solution was inoculated with soil or soil infusion. The arrangement of this series was therefore as follows:

[1] Studien über die Bakterien-flora des Ackerbodens, etc., by Hiltner and Störmer, Berlin, 1903, p. 453.

Peptone in Tap Water.

Number of Culture.	Cylinder Soil Number.	Quantity.
1.......	1	5 gms.
2.......	1	5 "
3.......	1	10 cc. infusion.
4.......	1	10 " "
5.......	2	5 gms.
6.......	2	5 "
7.......	2	10 cc. infusion.
8.......	2	10 " "
9.......	3	5 gms.
10.......	3	5 "
11.......	3	10 cc. infusion.
12.......	3	10 " "
13.......	4	5 gms.
14.......	4	5 "
15.......	4	10 cc. infusion.
16.......	4	10 " "

Peptone in Salt Solution.

Number of Culture.	Cylinder Soil Number.	Quantity.
17.......	1	5 gms.
18.......	1	5 "
19.......	1	10 cc. infusion.
20.......	1	10 " "
21.......	2	5 gms.
22.......	2	5 "
23.......	2	10 cc. infusion.
24.......	2	10 " "
25.......	3	5 gms.
26.......	3	5 "
27.......	3	10 cc. infusion.
28.......	3	10 " "
29.......	4	5 gms.
30.......	4	5 "
31.......	4	10 cc. infusion.
32.......	4	10 " "

Fifty cc. portions of these solutions were placed in flat-bottomed Jena flasks, stoppered with cotton plugs, and sterilized in the autoclave at two atmospheres of pressure. On cooling, the corresponding quantities of soil or infusion were added and the cultures placed in incubator and kept at 26° C. Ammonia determinations were made at the end of fifty-eight and eighty-two hours.

Ammonia Nitrogen Found.

In 58 Hours.

Soil.	Culture.	NH_4OH. cc.		Nitrogen. mg.
1	1......	7.70	=	22.08
1	3......	5.70	=	16.35
2	5......	10.70	=	30.69
2	7......	5.20	=	14.91
3	9......	13.15	=	37.71
3	11......	5.95	=	17.06
4	13......	13.60	=	39.00
4	15......	6.55	=	17.36
1	17......	14.50	=	41.59
1	19......	14.60	=	41.87
2	21......	14.55	=	41.73
2	23......	15.05	=	43.16
3	25......	15.15	=	43.44
3	27......	15.10	=	43.30
4	29......	15.10	=	43.30
4	31......	14.95	=	42.88

In 82 Hours.

Soil.	Culture.	NH_4OH. cc.		Nitrogen. mg.
1	2......	12.85	=	36.85
1	4......	7.75	=	22.23
2	6......	14.80	=	42.45
2	8......	5.55	=	15.92
3	10......	16.50	=	47.32
3	12......	9.80	=	28.11
4	14......	17.10	=	49.04
4	16......	9.00	=	25.81
1	18......	16.30	=	46.75
1	20......	14.95	=	42.88
2	22......	15.75	=	45.17
2	24......	14.50	=	41.59
3	26......	15.75	=	45.17
3	28......	15.10	=	43.30
4	30......	15.85	=	45.46
4	32......	16.10	=	46.17

A comparison of the soil inoculations, viz., cultures 1, 5, 9 and 13, will show that the relations between series 1, 2 and 3 are the same as those noted in the other experiments. The relations between series 3 and 4 (cultures 9 and 13) had changed, the latter yielding more ammonia nitrogen than the former. The change in question was evidently due to the application of manures and fertilizers ten days previous to the drawing of the soil samples. The soils of series 3 had received an application of solid manure alone, while the soils of series 4 received an application of solid and liquid manure, thereby changing the relations between the amounts of available nitrogen present in the soils of the two series. The same relations are again brought out in the duplicate cultures at the end of eighty-two hours. The following tabulation brings this out more clearly:

Ammonia Nitrogen Produced.

Soil.	In 58 Hours.	In 82 Hours.
1....................	22.08 mg.	36.85 mg.
2....................	30.69 "	42.45 "
3....................	37.71 "	47.32 "
4....................	39.00 "	49.04 "

Where the soil infusions were used the yields of ammonia nitrogen were smaller and the relations brought out in the soil inoculations failed to appear. The following quantities of ammonia nitrogen were found:

Soil.	In 58 Hours.	In 82 Hours.
1....................	16.35 mg.	22.23 mg.
2....................	14.91 "	15.92 "
3....................	17.06 "	28.11 "
4....................	17.36 "	25.81 "

The bacteria development was not as vigorous nor as regular here. The greater proportion of soluble salts in series 2, as compared with that in series 1, evidently exerted a depressing effect on the development of the soil organisms, since the yield in series 2 was smaller at the end of fifty-eight hours, as well as at the end of eighty-two hours. The yield of ammonia nitrogen was greater in series 4 than it was in series 3 at the end of fifty-eight hours, but smaller in 4 at the end of eighty-two hours.

The inoculations into the peptone salt solutions failed to yield definite results. Because of the more favorable medium the bac-

terial development proceeded very rapidly, thus obliterating any differences that may have existed at an earlier stage of growth. It will be noted that the soil and soil infusion yielded here practically the same results at the end of the first period. At the end of the second period there were greater variations in the soils of series 1, 2 and 3, the differences being in favor of the soil inoculations.

These results would indicate that the liberation of ammonia in peptone solutions finds an analogy in the decay of the organic nitrogenous compounds in the corresponding soil only when both soil and its bacteria are allowed to act on the solution; in other words, comparatively large quantities of soil must be used for inoculation. The use of soil infusion fails to yield the same results, evidently because the bacteria, when detached from their environment, do not maintain the same species relations. This fact is of great significance, not only for soil inoculation problems, but for all soil improvement problems. It shows that the bacterial flora of any soil bears an intimate relation to its composition, and that an enhancement of the desirable bacterial activities in the soil can only be encouraged by the proper improvement in the physical and chemical composition of the soil.

Another fact brought out in this experiment, and worthy of notice from the experimental standpoint, is the rapid obliteration of differences in the bacterial products when the organisms are placed in a medium favorable for their rapid growth. Hence, the use of media that would permit a study and differentiation of the various processes from day to day is essential in investigations of soil-bacteriological problems.

Series 4.

Further studies of ammonification in peptone solutions were made with four box soils, and one shale soil, secured from the Experiment Station lawn. The box soils are composed of half sand and half shale loam, are well provided with phosphoric acid, potash and lime, but poor in humus and available, or even total, nitrogen. They have been used for the past three years in vegetation experiments, and it was found that soils 53 and 54 yielded much heavier crops of millet than any of the other box soils, and that they evidently gained large quantities of nitrogen from atmospheric sources, through the activity of non-symbiotic nitrogen-fixing organisms. The lawn soil is well

provided with nitrogen and lime, and probably, also, with phosphoric acid and potash. The five soils enumerated here were inoculated in ten-gram quantities in 100 cc. portions of sterile peptone. The cultures were kept in the incubator at 26° C. and analysed at the end of three and four days, respectively. The following amounts of ammonia nitrogen were found:

	In three days.		In four days.	
Box Soil No.	NH_4OH.	Nitrogen.	NH_4OH.	Nitrogen.
1..........	7.65 cc.	21.94 mg.	11.50 cc.	32.98 mg.
2..........	6.95 "	19.93 "	11.20 "	32.12 "
28..........	7.00 "	20.08 "	12.60 "	36.14 "
53..........	6.90 "	19.79 "	12.45 "	35.71 "
Lawn soil....	14.10 "	40.44 "	24.95 "	71.56 "

The yields of ammonia nitrogen in the box soils indicate no constant differences. Notwithstanding the greater crop-production on *soil 53, it showed a slighter ammonifying power than any of the other* box soils at the end of three days. At the end of four days, the yield in soil 53 was greater than that in soil 1 or that in soil 2, and smaller than that in soil 28. The lawn soil, under the same conditions, showed a decidedly greater ammonifying power. At the end of three days the yield was 40.44 mg., or more than double that in the box soils 2, 28 and 53. At the end of four days the yield was 71.56 mg., or more than double that in box soils 1, 2 and 53. The very striking differences thus brought out between the light and heavy soils indicates, also, characteristic variations between the quantity and quality of the micro-organisms found in heavy and light soils.

Series 5.

The rapid decomposition in the peptone solutions and the early obliteration of the differences sought for, rendered advisable the investigation of other nitrogenous compounds to be used in place of the peptone. Casein and albumin seemed to offer some promise of adaptability for the purpose, and accordingly they were tried in the following manner: Fifty cc. portions of tap-water were sterilized in the autoclave and .5 grams of casein or egg albumin added to each. These were not sterilized, since it was desired to see whether the comparatively small number of bacteria thus introduced would at all affect the decomposition processes due to the great number of organ-

isms introduced with the five grams of soil. The latter was weighed off on the torsion balance and the culture solutions were inoculated and kept in the dark at room temperature. Ammonia determinations were made in the several cultures at the end of five days. Similar determinations of ammonia were also made in corresponding sterile portions of casein and albumin, and the amounts thus found, viz., 0.72 mg. ammonia-nitrogen, for the casein, and 1.01 mg. for the albumin, were subtracted from each corresponding culture. The soils used for inoculation were obtained from cylinders 1a, 2a, 3a and 4a, and were the same as those used in series 2, with the difference that the inoculations in series 2 were performed a few hours after the soil samples were drawn, while in the present series the soils were used after they had stood in the stoppered jars for a number of days. It is possible that the bacterial relations in these soils had changed sufficiently by that time to make a marked difference in the results, although Lohnis is inclined to think[1] that these relations do not change perceptibly for weeks, or even for months.

Following are the amounts of ammonia-nitrogen found:

	Casein.			Albumin.		
Soil No.			Nitrogen.			Nitrogen.
1a......	4.90 cc. NH_4OH	=	14.16 mg.	.45 cc. NH_4OH	=	1.30 mg.
1a......	3.20 " "	=	9.24 "	.40 " "	=	1.15 "
2a......	3.85 " "	=	11.12 "	.55 " "	=	1.59 "
2a......	3.50 " "	=	10.11 "	.60 " "	=	1.73 "
3a......	7.50 " "	=	21.67 "	.65 " "	=	1.88 "
3a......	5.80 " "	=	16.75 "	.55 " "	=	1.59 "
4a......	3.55 " "	=	10.25 "	.80 " "	=	2.31 "
4a......	4.00 " "	=	11.56 "	.60 " "	=	1.73 "

The marked difference between the casein and albumin as a source of nitrogen to the decay bacteria is apparent at a glance. At the same time, the results obtained here are not at all uniform. The duplicate yields of ammonia-nitrogen from soil 1a were 14.16 mg. and 9.24 mg., respectively, for the casein, a variation far beyond the experimental error. A very wide variation also occurs in the two inoculations with soil 3a. The differences in the ammonifying power of these four soils, clearly and consistently brought out in the peptone solutions, are merely indicated here. Excluding the larger yield in 1a, we obtain results that are somewhat concordant. The ammonifying power of soil 2a becomes, then, greater than that of 1a, considerably smaller than that of 3a, and somewhat smaller than that

[1] Centr. f. Bact., etc., part II., vol. XV., p. 363.

of 4a. In the albumin inoculations there are indications, at least, of certain variations, although the decay processes here had hardly made sufficient headway to bring out decisive differences. Nevertheless, it will be noted that the yield of ammonia-nitrogen in 1a was smaller than that in the other soils, and that the yield in 3a and 4a were, on the average, perceptibly greater than that in 2a.

Series 6.

This series was intended as supplementary to series 5. Fresh 50 cc. portions of tap-water were sterilized as heretofore, excepting that the casein and albumin were added here before sterilization. The sterile culture media were inoculated on cooling with five grams of soil each. The latter was the same as that used in series 3. The several flasks were placed in the incubator and kept there at 26° C. Ammonia determinations were made in the casein media at the end of thirty and fifty-four hours, respectively, and in the albumin media at the end of fifty-four and seventy-eight hours, respectively. The following amounts of ammonia-nitrogen were found:

Casein.

Soil No.	In 30 Hours.		Nitrogen.	In 54 Hours.		Nitrogen.
1a......	6.70 cc. NH_4OH	=	19.21 mg.	10.80 cc. NH_4OH	=	30.97 mg.
2a......	6.15 " "	=	17.64 "	12.15 " "	=	34.85 "
3a......	9.20 " "	=	26.38 "	12.75 " "	=	36.57 "
4a......	8.90 " "	=	25.52 "	13.65 " "	=	39.15 "

Albumin.

Soil No.	In 54 Hours.		Nitrogen.	In 78 Hours.		Nitrogen.
1a......	6.05 cc. NH_4OH	=	17.35 mg.	7.75 cc. NH_4OH	=	22.23 mg.
2a......	Lost		....	Lost		....
3a......	5.45 " "	=	15.63 "	8.50 " "	=	24.38 "
4a......	7.85 " "	=	22.51 "	11.95 " "	=	34.27 "

As in the preceding series, the casein proved a better source of nitrogen for the decay bacteria in the soil than did the albumin. The amounts of ammonia-nitrogen produced at the end of thirty hours were again irregular, soil 1a having yielded a greater amount of it than did soil 2, and soil 4 having yielded a smaller amount than did soil 3. On the other hand, the yields of ammonia-nitrogen at the end of fifty-four hours seemed to correspond, relatively, to those set free in the peptone solutions of series 3. These results would indicate that

further study might render the use of casein acceptable under certain conditions for the comparison of the ammonifying power of various soils.

Two of the ammonia determinations were lost in the albumin cultures. The remaining determinations show that at the end of fifty-four hours soil 1a set free more ammonia than did soil 3a, and less of it than did soil 4a. At the end of seventy-eight hours the yield from soil 3a was greater than that from 1a, and less than that from 4a. The latter results are in agreement with those secured in the casein cultures at the end of 54 hours, and would indicate that further study might also find a useful application for albumin in the study of ammonification processes in the soil.

A Comparative Study of the Nitrogen-Fixing Power of the Several Soils.

Ammonification is only one phase of the relationship which soil bacteria bear to soil nitrogen. There are other phases which concern the transformation of soluble nitrogen compounds, such as nitrates, ammonium salts, soluble organic nitrogen, etc., into insoluble protein-nitrogen. Other phases, still, may concern the destruction of nitrates with the liberation of free nitrogen or the fixation of atmospheric nitrogen. But little is known of the species relationships in the soil, or of the conditions involving the predominance of one or another of these phases. It is known, for instance, that nitrogen-fixing bacteria of the *Clostridium Pastorianum* type are present in most soils, as are the nitrogen-fixing bacteria of the Azotobacter group, or the smaller bacilli having a limited but distinct power of fixing atmospheric nitrogen. It is not known what exact relationship exists between these groups of organisms, nor is it known under what conditions the nitrogen-fixation by each may attain its maximum. It is not known exactly how practical methods of husbandry may encourage the establishment of the proper bacterial equilibrium, nor is it even known definitely what such an equilibrium may really mean. All these questions are to find their answer in the future, and the experiments recorded below, in some respects merely preliminary, were intended to furnish material or to suggest other work that would contribute to the solution of these problems.

Series 7.

This series represents a comparative study of five soils, four of them collected in the vicinity of New Brunswick and the fifth secured from the vicinity of Vineland, New Jersey. The first four were all shale soils and were collected immediately before use as inoculation material. The Vineland soil was a light, sandy loam, and was collected two and a half years previously and kept in a glass-stoppered bottle, in a moist condition, at the variable room temperature. Five grams of soil were used in each case for inoculation into a 100 cc. portion of a mannite solution, containing, per liter of tap-water, 15 grams of mannite, .5 grams K_2HPO_4, .2 grams $MgSO_4$, .02 grams $CaCl_2$, a drop of ferric chloride and enough sodium hydroxide to render the whole faintly alkaline to phenolphthaleine. The soil was weighed off on the torsion balance, admitting maximum differences of 150 to 200 milligrams. Similar portions of soil were weighed off and treated according to the Kjeldahl method for total nitrogen. The soils were of the following origin:

1. Meadow soil, secured from a meadow along the Raritan river. The soil had been heavily limed and thoroughly cultivated for two years and planted to belladonna.

2. Garden soil, secured from higher ground along the Raritan river. This soil has been kept in a good state of cultivation and occasionally dressed with stable manure.

3. Heath soil, secured from a dry red shale heath bearing but little vegetation and composed of coarse fragments of partly decomposed shale.

4. Lawn soil, secured from the Experiment Station lawn. This soil, like the others, is of red shale origin, but has received dressings of fertilizer, and after the fire, in 1903, had large quantities of plaster admixed with it.

5. The Vineland soil already referred to.

The nitrogen determinations in the duplicate five-gram quantities of these soils showed them to contain the following amounts of nitrogen:

		Average.	
Soil 1	5.90 cc. NH_4OH	5.97 cc. NH_4OH	= 7.74 mg. N
" 1	6.05 " "		
" 2	6.00 " "	6.17 " "	= 8.00 " "
" 2	6.35 " "		
" 3	.90 " "	.90 " "	= 1.17 " "
" 3	.90 " "		
" 4	6.00 " "	5.90 " "	= 7.65 " "
" 4	5.80 " "		
" 5	2.20 " "	2.10 " "	= 2.72 " "
" 5	2.00 " "		

The above determinations show very satisfactory agreement if it is remembered that the standard ammonia contained only .001297 grams of nitrogen per cc., and the soils for analysis were weighed off on the torsion balance. It will be observed that soils 1, 2 and 4, all shale soils of practically the same origin and all in a good state of cultivation, were very much alike in their nitrogen content. The heath soil was remarkably poor in nitrogen, containing only 1.17 milligrams of it in five grams of material. The Vineland soil was much poorer in nitrogen than the shale soils. After inoculation the *cultures were kept in the dark, at room temperature, from June 28th* until July 12th, 1905. At the latter date the cotton plugs were withdrawn, mercury and sulphuric acid were added and the contents digested. The following table gives the amounts of nitrogen found in the several cultures as well as the amounts of nitrogen fixed in each:

	Nitrogen Found.	Average.	Nitrogen in Soil.	Nitrogen Fixed.
Soil 1	*11.50 cc.* NH_4OH	11.77 cc. = 15.26 mg. N	7.74 mg.	7.52 mg.
" 1	12.06 " "			
" 2	10.85 " "	10.85 " = 13.42 " "	8.00 "	5.42 "
" 2	10.85 " "			
" 3	3.85 " "	3.65 " = 4.73 " "	1.17 "	3.56 "
" 3	3.45 " "			
" 4	15.65 " "	15.77 " = 20.45 " "	7.65 "	12.80 "
" 4	15.90 " "			
" 5	5.35 " "	5.35 " = 6.94 " "	2.72 "	4.22 "
" 5	5.35 " "			

A comparison of soils 1, 2 and 4, all of the same origin, and containing nearly the same amounts of organic nitrogen, shows forcibly how different methods of soil treatment may affect the bacterial activities in the soil. It shows that the nitrogen-fixing power of soil 2 is much less than that of soil 1, or of soil 4. The difference is easily explained by the fact that soil 2 had not recently received applications of lime, and was probably also poorer in phosphoric acid and in potash; hence its reduced nitrogen-fixing power—less than one-half that of soil 4. The latter showed a marked superiority over soil 1, apparently, also, because of its better supply of lime, of phosphoric acid and of potash, and the resulting vigorous bacterial flora. The heath soil showed a slighter nitrogen-fixing power than any of the others, a result to be expected in view of its dry, unproductive state. The gain of nitrogen was none the less considerable, even here, when taken in connection with its nitrogen content. The nitrogen fixation by the Vineland soil was also quite marked, although much below that

in the productive shale soils. On the whole, the yields of the combined nitrogen were rather large in soils 1 and 4. In the latter, particularly, the fixation was at the rate of more than eight milligrams of combined nitrogen per gram of mannite consumed (each 100 cc. portion of the culture medium contained 1.5 grams of mannite).

The above experiment shows, likewise, that the Vineland soil kept in the laboratory for two years and a half still retained much of its nitrogen-fixing power. It would be interesting to inquire, in this connection, to what extent the bacterial relationships are affected in small samples of soil kept in glass-stoppered jars for longer periods, and whether such old soil samples may be used legitimately for certain bacteriological investigations.

Series 8.

It was noted on previous occasions that unequal quantities of soil showed differences in the amounts of nitrogen fixed. This made it desirable to ascertain the limits of nitrogen fixation by variable quantities of soil. Accordingly two samples of soil were secured for the purpose on the College Farm, one of them from a field where asparagus had been growing for a number of years, the other from an alfalfa field of four or five years' standing. The asparagus soil is situated on somewhat higher ground, and contains a larger proportion of sand than the alfalfa soil. It has received rather thorough cultivation for a number of years, and was occasionally irrigated in dry seasons. The alfalfa, like the asparagus soil, is derived from red shale, but is more compact and is not aerated as well. Varying portions of these soils were inoculated into 100 cc. quantities of a mannite solution prepared as in series 7, and kept in the dark, and at room temperature, from July 5th until July 18th, 1905. The analytical work was carried out in the customary manner and proper allowances were made for the small quantities of combined nitrogen found in the reagents. Determinations of total nitrogen were also made in separate portions of the respective soils, and the corresponding subtractions made for the amounts of nitrogen added in the inoculating material. The alfalfa soil was found to contain 8.88 mg. of total nitrogen in five grams of material and the asparagus soil 7.65 mg. of total nitrogen in the same amount of material.

Asparagus Soil Inoculations.

Culture No.	Soil Added.	NH_4OH Equivalent.	Nitrogen in Culture. NH_4OH Equivalent.	Nitrogen Fixed.
1....	.5 gms.	.59 cc.	2.15 cc.	
2....	.5 "	.59 " = 0.76 mg. N	2.40 " = 2.85 mg. N	2.09 mg.
3....	1.0 "	1.18 "	3.00 "	
4....	1.0 "	1.18 " = 1.53 " "	2.75 " = 3.61 " "	2.08 "
5....	2.0 "	2.36 "	4.10 "	
6....	2.0 "	2.36 " = 3.06 " "	4.15 " = 5.18 " "	2.12 "
7....	3.0 "	3.54 "	5.90 "	
8....	3.0 "	3.54 " = 4.59 " "	6.50 " = 7.80 " "	3.21 "
9....	5.0 "	5.90 "	8.95 "	
10....	5.0 "	5.90 " = 7.65 " "	8.75 " =11.13 " "	3.48 "
11....	8.0 "	9.44 "	12.35 "	
12....	8.0 "	9.44 " =12.24 " "	12.85 " =15.85 " "	3.61 "
13....	10.0 "	11.80 "	14.60 "	
14....	10.0 "	11.80 " =15.30 " "	14.20 " =18.11 " "	2.81 "
15....	12.0 "	14.16 "	18.00 "	
16....	12.0 "	14.16 " =18.36 " "	Lost " =22.64 " "	4.28 "
17....	15.0 "	17.70 "	19.65 "	
18....	15.0 "	17.70 " =22.95 " "	20.00 " =24.93 " "	1.98 "
19....	20.0 "	23.60 "	24.65 "	
20....	20.0 "	23.60 " =30.60 " "	24.75 " =31.07 " "	0.37 "

As indicated by the above data, the fixation of nitrogen was not very extensive in this experiment. The amounts fixed in the .5, 1.0 and 2.0 grams soil inoculations were practically the same, showing that within the given limits the asparagus soil showed a constant power of nitrogen fixation. As the amount of soil used for inoculation was increased, there was also a perceptible increase in the amount of atmospheric nitrogen fixed. With an inoculation of three grams of soil the fixation was 3.21 mg. of nitrogen, with five grams of soil it was 3.48 mg., and with an inoculation of eight grams it was 3.61 mg. With an inoculation of ten grams of soil the fixation was smaller than the preceding, but with an inoculation of twelve grams the amount fixed was increased again to 4.28 mg. The further increase in the amount of soil used for inoculation led to a marked decrease until, in cultures 19 and 20, the nitrogen gained averaged only 0.37 mg. While there is therefore a certain relation between the amount of nitrogen fixed and the ratio of soil to culture solution, it is by no means constant, and is quite variable in different soils. There is evidently a point for every soil where increasing quantities of inoculating material are no longer followed by increasing amounts of nitrogen fixed. It would even seem that when the proportion of soil to culture solution is sufficiently large there is no gain of nitrogen at all, but a decided loss, due to the decomposition of the soil nitrogen

by the decay bacteria and the volatilization of ammonia or of free nitrogen. The following tabulation brings out the analogous relations in the richer alfalfa soil:

Alfalfa Soil Inoculations.

Culture No.	Soil Added.	NH_4OH Equivalent.	Nitrogen in Culture, NH_4OH Equivalent.	Nitrogen Fixed.
1....	.5 gms.	.68 cc.	2.25 cc.	
2....	.5 "	.68 " = 0.89 mg. N	2.25 " = 2.87 mg. N	1.98 mg.
3....	1.0 "	1.37 "	3.45 "	
4....	1.0 "	1.37 " = 1.78 " "	3.40 " = 4.36 " "	2.58 "
5....	2.0 "	2.74 "	5.10 "	
6....	2.0 "	2.74 " = 3.55 " "	5.30 " = 6.63 " "	3.08 "
7....	3.0 "	4.11 "	7.20 "	
8....	3.0 "	4.11 " = 5.33 " "	7.45 " = 9.34 " "	4.01 "
9....	5.0 "	6.85 "	10.30 "	
10....	5.0 "	6.85 " = 8.88 " "	10.75 " =13.42 " "	4.54 "
11....	8.0 "	10.95 "	14.00 "	
12....	8.0 "	10.95 " =14.21 " "	14.00 " =17.61 " "	3.40 "
13....	10.0 "	13.70 "	15.60 "	
14....	10.0 "	13.70 " =17.77 " "	16.25 " =21.03 " "	3.26 "
15....	12.0 "	16.44 "	19.15 "	
16....	12.0 "	16.44 " =21.32 " "	19.00 " =23.99 " "	2.67 "
17....	15.0 "	20.55 "	22.40 "	
18....	15.0 "	20.55 " =26.65 " "	Lost " =28.18 " "	1.53 "
19....	20.0 "	27.40 "	31.05 "	
20....	20.0 "	27.40 " =35.54 " "	34.80 " =39.65 " "	4.11 "

Increasing fixation is also apparent in the alfalfa soil with the increasing amount of inoculating material. There is a difference here, however, in that the amounts of nitrogen fixed were larger than those in the asparagus soil, and that the point of maximum fixation was reached sooner. The addition of .5 grams of soil to 100 cc. of the culture medium led to a fixation of 1.98 mg. of nitrogen; the addition of 1.0 gram of soil to the fixation of 2.58 mg. of nitrogen; the addition of 2.0 grams of soil to the fixation of 3.08 mg. of nitrogen; the addition of three grams of soil to the fixation of 4.01 mg. of nitrogen, and the addition of five grams of soil to the fixation of 4.54 mg. of nitrogen. After that there was a decline to 3.40 mg., 3.26 mg., 2.67 mg. and 1.53 mg., for 8, 10, 12 and 15 grams of soil, respectively. Strangely enough, there was a sudden increase, like that in the asparagus soil inoculations, in one instance. The increase in the former followed the use of twelve grams of inoculating material, while in the alfalfa soil it followed the use of twenty grams of inoculating material. The marked exception in either case is probably due to the difference in the character of the bacterial growth

developing in the culture flasks. The agents of fixation in all but two sets of the forty cultures were undoubtedly the anaerobic butyric ferments, while in the two particular pairs of cultures the fixation was also due in part to the development of Azotobacter species. With the exception, therefore, of the four single cultures in question, there was in either soil a gradual rise, followed by a gradual decline in the amounts of nitrogen fixed. It remains to note here that fresh solutions of NH_4OH were made up several times in the course of the analytical work, and hence the numbers in the above tables represent solutions of varying strength.

Series 9.

The somewhat irregular results with the larger quantities of inoculating material rendered it desirable to duplicate a portion of the work. Accordingly 100 cc. portions of mannite were inoculated, as in the preceding series, with 5, 10, 15 and 20 grams, respectively, of each soil. After inoculation the cultures were kept in the dark from July 19th to July 31st, 1905. The analyses yielded the following results:

Asparagus Soil Inoculations.

Culture No.	Soil Added.	NH_4OH Equivalent.	Nitrogen in Culture, NH_4OH Equivalent.	Nitrogen Fixed.
1....	5 gms.	5.90 cc. = 7.65 mg. N	8.95 cc. = 11.20 mg. N	3.55 mg.
2....	10 "	11.80 " = 15.30 " "	14.90 " = 18.65 " "	3.35 "
3....	15 "	17.70 " = 22.95 " "	21.20 " = 26.54 " "	3.59 "
4....	20 "	23.60 " = 30.60 " "	27.65 " = 34.62 " "	4.02 "

Alfalfa Soil Inoculations.

Culture No.	Soil Added.	NH_4OH Equivalent.	Nitrogen in Culture, NH_4OH Equivalent.	Nitrogen Fixed.
1....	5 gms.	6.85 cc. = 8.88 mg. N	9.60 cc. = 12.02 mg. N	3.14 mg.
2....	10 "	13.70 " = 17.77 " "	18.65 " = 23.35 " "	5.58 "
3....	15 "	20.55 " = 26.65 " "	27.35 " = 34.24 " "	8.59 "
4....	20 "	27.40 " = 35.54 " "	32.85 " = 41.13 " "	5.59 "

It will be seen that these results do not confirm those obtained earlier. The experiment conditions in the two series were identical, excepting that the soil used for inoculation in the present series had stood in the laboratory for about two weeks, and that the room temperature variations to which the cultures were exposed were not the same. Either or both of these differences in the experiment conditions may have influenced the character of growth in the culture flasks. It was observed, at any rate, that the development of the Azotobacter species was more prominent in the present series, which would account for the large quantities of nitrogen fixed.

AZOTOBACTER STUDIES.

The experiments reported here were carried out with cultures isolated at various times in 1903, 1904 and 1905.[1] The cultures of *A. vinelandii*, isolated at the beginning of 1903 and kept in the laboratory since that time, were found to have lost none of their nitrogen-fixing power. A similar comparison of fresh cultures of *A. Beyerincki* with those isolated a year earlier showed that also this species had retained its original power of fixing atmospheric nitrogen. As to the quantitative production of combined nitrogen, *A. vinelandii* is markedly superior to either *A. Beyerincki* or *A. chroococcum*, with an output frequently more than double that produced by either of the other species. *A. Beyerincki* and *A. chroococcum*, while quite *different in their cultural characteristics*, are physiologically alike in so far, at least, as their power of nitrogen fixation is concerned. Like *A. vinelandii*, these two species may also increase their output of combined nitrogen when growing together with certain smaller bacilli, more fully discussed in the following pages. It still remains to be demonstrated whether similar relations between the Azotobacter species and other organisms exist, also, in the soil under actual field conditions. Future studies in this direction will at any rate find useful hints in the laboratory experiments with pure or mixed cultures, and will undoubtedly recognize them as an aid in the solution of the more complex soil bacteriological problems.

Series 1.

Previous experiments had demonstrated that the fixation of nitrogen by Azotobacter species may be intensified by a more thorough aeration of the culture medium. The amounts of nitrogen fixed by these organisms bore a certain relation to the surface area of the culture solutions, and the increased output of combined nitrogen was evidently due to the large supply of either nitrogen or oxygen, or of both. The economy of nitrogen fixation—that is, the production of nitrogenous substance per unit of the sugar consumed—was directly influenced by the conditions of bacterial development, and the higher

[1] See N. J. Stat. Rep. 1903, p. 215; ibid, 1904, p. 235.

physiological efficiency of the organisms, under more favorable conditions of growth, could evidently be utilized for the elaboration of larger quantities of protein nitrogen. The question was still open, however, whether such higher physiological efficiency could be maintained indefinitely under the same conditions of experiment, or, more interesting still, whether it could be still further intensified and made a more or less permanent characteristic of the particular strain of organisms. It was clear enough that positive results in this direction would be a valuable asset in our study of soil fertility problems and would lend a peculiar significance to research in soil inoculation. The experiment in question was planned, therefore, to maintain a series of reinoculations of *Azotobacter vinelandii* in three sets of culture flasks. The latter were to have a capacity of 1,000 cc., 500 cc. and 250 cc., respectively, and reinoculations were to be made in each set at intervals of five days. After ten such reinoculations, the final transfer was to be made from each into 500 cc. flasks containing the same amount of culture solution. Nitrogen determinations were to be made in each set when the cultures were ten days old. The final analyses were to show whether the organisms growing for ten generations in Erlenmeyer flasks, with a capacity of 1,000 cc., could still fix more nitrogen than the organisms growing for ten generations in 500 cc. flasks, or 250 cc. flasks, when each is inoculated into the same amount of culture solution in a 500 cc. Erlenmeyer flask. Accordingly, 100 cc. portions of a mannite solution, prepared in the customary manner,[1] were placed, respectively, in 1,000 cc. Erlenmeyers, 500 cc. Erlenmeyers and 250 cc. Erlenmeyers, sterilized, cooled and inoculated with a vigorous culture of *Azotobacter vinelandii* on February 3d, 1905. All of the flasks were placed in the incubator at 28° C. Growth in all the flasks was already apparent at the end of twenty-four hours, and at the time of the first reinoculation, on February 8th, the pigment in the 1,000 cc. flasks was much darker than that in the 500 cc. flasks, while the pigment in the 250 cc. flasks was lighter than that in either. At the time when the fifth reinoculation was made the growth in the 500 cc. flask was rather feeble and that in the 1,000 cc. flask not very vigorous. At the time of the ninth reinoculation the culture in the 500 cc. flask was more vigorous than that in the 1,000 cc. flask. The nitrogen determinations were made in ten days' old cultures, the first four sets of three flasks having their nitrogen differentiated as precipitable and non-precipitable by phos-

[1] N. J. St. Rep. 1904, p. 263.

pho-tungstic acid, while the remaining sets were merely treated for total nitrogen. The amounts of nitrogen found at the different dates are given in the following table:

Inoculated.	Analysed.	1,000 cc. Flask Nitrogen Fixed.	500 cc. Flask Nitrogen Fixed.	250 cc. Flask Nitrogen Fixed.
Feb. 3........	Feb. 13	18.33 mg.	20.99 mg.	18.30 mg.
" 8........	" 18	20.66 "	17.98 "	17.67 "
" 13........	" 23	18.93 "	17.04 "	17.35 "
" 18........	" 28	18.61 "	17.35 "	14.83 "
" 23........	Mar. 6	17.35 "	14.83 "	12.62 "
" 28........	" 10	11.52 "	10.25 "	12.47 "
Mar. 6........	" 16	11.36 "	10.74 "	11.21 "
" 10........	" 20	10.67 "	12.56 "	15.22 "
" 15........	" 25	11.14 "	13.34 "	14.60 "
" 20........	" 30	11.14 "	12.24 "	15.07 "
" 25........	Apr. 4	11.68 "	12.20 "	10.24 "
" 25........	" 4	11.03 "	12.95 "	11.52 "
" 30........	" 14	10.24 "	12.95 "	9.28 "
" 30........	" 14	11.03 "	11.20 "	9.91 "

The above analyses show that the frequent reinoculations into fresh media did not increase the nitrogen-fixing power of *A. vinelandii.* There was a rapid falling off from the first to the fifth reinoculation, and after that there was a fairly constant yield, tending to shrink still more in the final cultures. In the 1,000 cc. flasks the yield of nitrogen was, respectively, 18.33 mg., 20.66 mg., 18.93 mg., 18.61 mg. and 17.35 mg. in the first five inoculations. The largest of these, viz., 20.66 mg., represents a fixation of almost fourteen milligrams of nitrogen per gram of mannite consumed. The remaining five cultures of the first ten inoculations were fairly constant, and averaged slightly over eleven milligrams of nitrogen, or less than eight milligrams per gram of mannite consumed. The remaining two reinoculations in duplicate were made into 500 cc. flasks, yet the output of combined nitrogen was not materially affected thereby. The second column, representing the inoculations in the 500 cc. flasks, shows, likewise, a decrease in the yield of combined nitrogen from reinoculation to reinoculation. In the sixth generation the output had diminished from 14.83 mg. to 10.25 mg., after which it increased again and remained throughout greater than that in the 1,000 cc. flasks. A similar decrease was also apparent for five generations in the 250 cc. flasks. After that the yield was actually greater here than it was in the corresponding 500 cc. flasks, but suffered a further diminution when reinoculated, after

ten generations, into the larger 500 cc. flasks. This experiment would therefore justify the belief that old cultures of *A. vinelandii*—that is, cultures that had for some time remained dormant—are stimulated to a larger fixation of atmospheric nitrogen when transferred to suitable fresh media, and that the output of combined nitrogen is increased under these conditions with the more thorough aeration of the culture solution (larger surface exposure). When these actively-growing organisms are at frequent intervals transferred into fresh solutions the output of combined nitrogen diminishes and reaches a point after which it is fairly constant. Where the areation is less thorough a similar decrease is first apparent, but when the point of equilibrium is finally reached the output is inversely proportional to the surface exposure of the culture medium. These deductions find some support in the fact that duplicates of the final reinoculations, when allowed to stand for more than a month and then transferred to fresh media, increased, in some instances, their output of combined nitrogen. Furthermore, these last inoculations, while all made into 500 cc. flasks, still retained, apparently, a part of the modification previously received, and were capable of transmitting them for at least one more generation in two out of three cultures, as will be seen from the following figures:

Inoculated.	Analysed.	500 cc. Flask.	500 cc. Flask.	500 cc. Flask.
13th generation, April 14......	May 20	12.34 mg.	12.66 mg.	10.10 mg.
14th generation, May 20......	" 26	12.34 "	11.70 "	10.42 "

It would seem, thus, that there may be a possibility of intensifying the nitrogen-fixing power of Azotobacter organisms and of lending some permanence to this increased capacity, provided that reinoculations are not made at too frequent intervals. This last is merely a surmise, however, the experimental evidence at hand being entirely too meager to justify any definite conclusion. It is proposed to duplicate this work under similar conditions of experiment, but with reinoculations to be made at intervals of at least four weeks. Positive results may encourage similar experiments with other members of this group, in pure and mixed culture, and especially in joint activity with certain smaller bacilli, which have been found to enhance the nitrogen-fixing power of Azotobacter species when growing together with them.

Series 2.

It was intended to compare, in this series, the physiological efficiency of old and fresh cultures of *A. Beyerincki*, and to determine whether the old isolations, maintained in the laboratory for some months, could still fix as much nitrogen as the freshly isolated cultures of the same organism. The comparison was made here between the original culture of *A. Beyerincki* isolated a year previously, a culture of *A. Beyerincki* freshly isolated from a greenhouse soil, and a culture of *A. Beyerincki* freshly isolated from a crude culture obtained from a reclaimed meadow soil some months previously. The inoculations were made on February 16th, 1905, into 100 cc. portions of mannite contained in flat-bottomed 500 cc. Jena flasks. Inoculations were made in duplicate from each of the three cultures, and two additional solutions were also inoculated with both *A. Beyerincki*, freshly isolated from the greenhouse soil, and B. 36, a medium-sized bacillus, very much resembling B. 30, described in a previous report.[1] The several cultures were analysed on February 26th, with the following results:

Culture No.	Inoculation.	Nitrogen Fixed.
1	*A. Beyerincki*, old culture	3.63 mg.
2	" " "	3.31 "
3	" fresh, greenhouse soil	3.63 "
4	" " " "	6.78 "
5	" " meadow soil	2.37 "
6	" " " "	2.68 "
7	" " greenhouse soil + B. 36	7.89 "
8	" " " " + B. 36	8.04 "

The differences in the nitrogen-fixing power of the three cultures of *A. Beyerincki*, as indicated by the above analyses, are not, with one exception, very striking. The old isolation had apparently retained its full power of fixation, which was even greater than the corresponding capacity of the organisms from the meadow soil. In the case of the fresh isolation from the greenhouse soil there was in one of the cultures almost double the yield of combined nitrogen as compared with that furnished by the old isolation. This marked difference is apparently due to the more vigorous growth that had taken place in that particular culture. It is not known why such a decided impetus to growth should have occurred here, but it should be stated, in this connection, that similar occurrences were repeatedly observed in other series, and with *A. Beyerincki* more than with the

[1] N. J. Stat. Rep. 1903, p. 240.

other Azotobacter species. It would seem almost that this species, because of its greater power of variation, is better adapted than the others for investigations concerning differentiations in physiological efficiency. Where the fresh greenhouse soil isolation was inoculated together with B. 36, the yield of combined nitrogen was increased markedly in each of the two cultures. The total yield, 2.60 mg. and 2.65 mg., respectively, or less than two milligrams of combined nitrogen per gram of mannite consumed, is not large when compared with similar yields by *A. vinelandii*. There is no doubt, however, that a larger culture period would have reduced this difference.

Series 3.

The peculiar variations in the nitrogen-fixing power of *A. Beyerincki* are still more clearly shown in the present series. It was noted, in the course of observations on this organism, that a certain culture derived from the fresh greenhouse isolation made much more growth, under given conditions, than other cultures derived from the same source. It was deemed advisable, therefore, to compare one of the latter with the more vigorous cultures in question, and to supplement the experiment with similar cultures to which had been added either B. 36 or B. 37, both found capable, under certain conditions, of enhancing the nitrogen-fixing power of the Azotobacter species. The arrangement of the several cultures (100 cc. mannite in each case) was as follows:

Culture No.	Inoculation.	Nitrogen Fixed.
1	*A. Beyerincki*, greenhouse soil	1.57 mg.
2	" " "	2.20 "
3	" more vigorous culture	7.85 "
4	" " " "	7.72 "
5	As in 1 and 2+B. 36	9.10 "
6	" " "	8.63 "
7	As in 3 and 4+B. 36	8.63 "
8	" " "	7.85 "
9	As in 1 and 2+B. 37	10.51 "
10	" " "	9.26 "
11	As in 3 and 4+B. 37	9.73 "
12	" " "	9.26 "

The difference between the two cultures of the same organism is brought out very graphically in the above columns. The amounts of nitrogen fixed in the twenty-three-day period, by what may be termed the normal cultures, were quite small, only 1.57 mg. and 2.20 mg.,

respectively, in the two parallels, while the amounts fixed by the vigorous culture were 7.85 mg. and 7.72 mg., respectively. When, however, B. 36 was added to the normal culture of *A. Beyerincki* the amount fixed was increased to 9.10 mg. and 8.63 mg., respectively. The similar addition of B. 36 to the more vigorous culture failed to give a corresponding increase, although there was apparently a slight enhancement of the nitrogen fixation. The addition of B. 37 to the normal culture of *A. Beyerincki* led to an even greater increase than was produced by the addition of B. 36, while the addition of B. 37 to the more vigorous culture of *A. Beyerincki* led also here to a distinctly larger fixation of atmospheric nitrogen. It follows, from this, that under proper conditions *A. Beyerincki* is capable of vigorous nitrogen fixation, whose maximum falls much below that of *A. vinelandii*. Under circumstances not yet fully understood, the nitrogen-fixing power of this species may be very materially diminished, but may again be made to attain its maximum when enjoying the co-operation of certain other organisms. The greatest amount of elementary atmospheric nitrogen thus laid fast in organic combination may be about 6 mg. of combined nitrogen per gram of mannite consumed. In exceptional cases, as, for instance, in culture 9, the amount thus fixed may be seven milligrams per gram of mannite consumed.

Series 4.

The present series, like the preceding one, provides for a comparison of a pure culture of Azotobacter, when acting alone, or together, with B. 36 or B. 37. In this case, however, the Azotobacter species was *A. vinelandii*. Two culture solutions were also inoculated with *A. woodstownii*. As in the preceding series, the amount of solution used was 100 cc., containing 1.5 grams of mannite. The growing period was from March 2d to 15th, 1905.

Culture No.	Inoculation.	Nitrogen Fixed.
1	*A. vinelandii*	13.57
2	"	11.20
3	*A. vinelandii* + B. 36	13.41
4	" "	15.45
5	*A. vinelandii* + B. 37	8.20
6	" "	9.15
7	*A. woodstownii*	....
8	"	....

In this case the addition of B. 36 increased the nitrogen-fixing power of *A. vinelandii* but little. On the other hand, the addition

of B. 37 unmistakably depressed the yield of combined nitrogen. The two bacilli therefore assume a relation to *A. vinelandii* that is rather different in kind, whereas in their relation to *A. Beyerincki* they differ only in degree. The depression of the nitrogen fixation by B. 37 would indicate that there is either the production by the latter of substances injurious to *A. vinelandii* or simply a rapid consumption of the food that would otherwise be used by A. *vinelandii*. *A. woodstownii*, as on former occasions, failed to fix any nitrogen at all.

Series 5.

Further data on the relations brought out in the two preceding series are given below. The duration of this experiment was from March 21st to March 31st, 1905. The same amounts of mannite were used here and the conditions of the experiment were as in the other cultures:

Culture No.	Inoculation.	Nitrogen Fixed.
1	*A. vinelandii*	13.33 mg.
2	"	11.30 "
3	*A. vinelandii*+B. 36	16.17 "
4	" "	16.01 "
5	*A. vinelandii*+B. 37	9.10 "
6	" "	9.73 "
7	*A. Beyerincki*, old culture	4.87 "
8	" " "	4.39 "
9	*A. Beyerincki*, vigorous culture	5.65 "
10	" " "	10.67 "
11	*A. Beyerincki*, old culture+B. 36	9.26 "
12	" " " "	9.42 "
13	*A. Beyerincki*, old culture+B. 37	8.95 "
14	" " " "	9.42 "
15	*A. Beyerincki*, vigorous culture+B. 36	9.42 "
16	" " " "	8.63 "
17	*A. Beyerincki*, vigorous culture+B. 37	8.63 "
18	" " " "	8.16 "

The results in the other series are, in the main, confirmed also here. The co-operation of B. 36 enhanced the production of combined nitrogen by *A. vinelandii*, which amounted in cultures 3 and 4 to more than ten milligrams per gram of mannite used up. In the presence of B. 37, there was, on the contrary, a distinct decrease in the yield of combined nitrogen. The yields in the cultures of *A. Beyerincki* are fully as instructive. The fixation in the solutions inoculated with the old isolation was distinctly greater than that on previous occasions,

but was still below that in the cultures of the more vigorous strain of this species. Moreover, in the latter cultures the duplicates showed a very wide divergence, due to the peculiarities of *A. Beyerincki*, already noted elsewhere. In culture 9 there was a yield of 5.65 mg. of combined nitrogen, while in the parallel culture 10 the yield was 10.67 mg., or at the rate of more than seven milligrams of nitrogen per one gram of mannite, an amount not exceeded even in the following cultures, where the Azotobacter had the co-operation of B. 36 or B. 37. When inoculated together with B. 36 the old isolation was as effective as the corresponding combination with the more vigorous strain. In fact, it was slightly more effective, and more distinctly so in the combination with B. 37. It appears, likewise, that B. 36 made possible a larger yield of combined nitrogen by *A. Beyerincki* than did B. 37, although the latter was responsible for almost as great an increase here, whereas in the case of *A. vinelandii* it led to a distinct diminution in the yield of combined nitrogen.

Series 6.

A comparison was made in the present series of the yields of combined nitrogen by *A. chroococcum*, *A. chroococcum* var. and *A. woodstownii*, when growing alone or together with B. 36. The conditions of the experiment were the same as in the preceding series and its duration ten days.

Culture No.	Inoculation.	Nitrogen Fixed.
1	*A. chroococcum*	4.42 mg.
2	*A. chroococcum* var.	2.21 "
3	*A. woodstownii*	.... "
4	*A. chroococcum* + B. 36	11.20 "
5	*A. chroococcum* var. + B. 36	8.36 "
6	*A. woodstownii* + B. 36	.... "

The yield of combined nitrogen by *A. chroococcum* was similar to that by *A. Beyerincki*. *A. chroococcum* var. was not capable of fixing as large a quantity of atmospheric nitrogen, while *A. woodstownii* proved incapable of fixing any appreciable amount of it. When inoculated together with B. 36, *A. chroococcum* more than doubled its yield of combined nitrogen; *A. chroococcum* var. practically doubled its yield, while *A. woodstownii* still remained incapable of nitrogen fixation. It is noteworthy, in this connection, that the inferior nitrogen-fixing power of *A. chroococcum* var., as against that of

A. chroococcum, was still apparent, even when it was growing together with B. 36. On the whole, then, the latter organism was found to enhance the nitrogen-fixing power of *A. vinelandii*, *A. Beyerincki*, *A. chroococcum* and *A. chroococcum* var., but was found incapable of imparting this power to *A. woodstownii.*

Series 7.

Previous experiments had shown that nitrogen fixation by *A. vinelandii* is intensified as the aeration of the culture solution is improved. It was probable that other Azotobacter species would behave similarly in this respect, and this series was arranged, therefore, to furnish the corresponding data. Erlenmeyer flasks, of a capacity of 1,000 cc., 500 cc. and 250 cc. (in one instance 200 cc.), and containing 100 cc. portions of mannite, well sterilized, in the usual manner, cooled and inoculated as follows:

Culture No.	Inoculation.		Nitrogen Fixed.
1	*A. Beyerincki*	1,000 cc. flasks	6.91 mg.
2	"	"	5.81 "
3	*A. chroococcum*	"	8.32 "
4	"	"	8.00 "
5	*A. Beyerincki*	500 cc. "	6.43 "
6	"	"	5.02 "
7	*A. chroococcum*	"	7.38 "
8	"	"	7.35 "
9	*A. Beyerincki*	200 cc. "	6.43 "
10	"	200 cc. "	4.24 "
11	*A. chroococcum*	250 " "	5.18 "
12	"	250 " "	5.49 "

It will be noted, in the first place, that the yields of combined nitrogen by *A. Beyerincki* are quite irregular, the duplicates showing rather wide variations throughout. Thus, in culture 1 the yield was 6.91 mg., and in its duplicate, culture 2, it was 5.81 mg., a difference of more than one milligram. The corresponding yield in culture 5 was 6.43 mg., and in its duplicate, culture 6, it was 5.02, or a difference of almost a milligram and a half. The yield in culture 9 was 6.43 mg., and in its duplicate, culture 10, it was only 4.24 mg., or a variation of more than two milligrams. *A. chroococcum,* on the other hand, with considerable yields throughout, shows distinctly smaller variations, all of them less than one-half of a milligram. Comparing the yields according to the surface areas exposed, we find that *A. Beyerincki* yielded, on the average, 6.36 mg. of nitrogen in the 1,000 cc. flasks, 5.72 mg. of nitrogen in the 500 cc. flasks and 5.33 mg. of

nitrogen in the 200 cc. flasks. *A. chroococcum* yielded, on the average, 8.16 mg. in the 1,000 cc. flasks, 7.61 mg. in the 500 cc. flasks and only 5.33 mg. in the 250 cc. flasks. It is certain, therefore, that, like *A. vinelandii*, these species are affected in their growth by the supply of the atmospheric gases, and that the amount of combined nitrogen formed by these is likewise inversely proportional to the depth of the culture fluid. It is quite likely, furthermore, that the fixation of nitrogen per unit of mannite consumed could have been still further increased by passing air through the culture solution during the course of the experiment. However, in so far as the point in question is concerned, the proof furnished here is quite ample.

Series 8.

A proportionately larger fixation of atmospheric nitrogen is achieved by the Azotobacter species, not only through the better aeration of the culture solution, but also through the more limited supply of the organic substance used by the bacteria as their source of food and energy, as was already noted by Gerlach and Vogel.[1] The present series contains further data on this point. Of the six cultures used here, two contained 100 cc. of mannite each, two contained 200 cc. of mannite each and the remaining two contained 300 cc. of mannite each. The several cultures were inoculated with *A. vinelandii* on February 23d, and analysed on March 18th, 1905. During this interval the flasks were kept in the incubator at 27° to 28° C. On the latter date the several cultures were treated with phospho-tungstic acid, filtered, and the precipitates and filtrates, respectively, treated according to the Kjeldahl method. The following amounts of nitrogen were found:

Culture No.	Inoculation.		Nitrogen Fixed. Precipitate.	Nitrogen Fixed. Filtrate.	Nitrogen Fixed. Total.
1	*A. vinelandii*	100 cc. mannite	9.10 mg.	2.85 mg.	11.45 mg.
2	"	100 cc. mannite	10.83 "	1.88 "	12.71 "
3	"	200 " "	19.62 "	4.55 "	24.17 "
4	"	200 " "	19.46 "	4.39 "	23.85 "
5	"	300 " "	22.29 "	4.87 "	27.16 "
6	"	300 " "	22.60 "	4.24 "	26.84 "

The cultures were contained in 500 cc. Erlenmeyer flasks, and there was therefore an increasingly greater depth from 2 to 4, and from 4 to 6, but also a decreasing surface area, since the Erlenmeyer flasks are cylindrical. Another difference, even more important than

[1] Centr. f. Bact., etc., part II., vol. IX., p. 819.

the first in determining the output of combined nitrogen, was that *due to the absolute amounts of mannite present in the culture solutions.* The first pair contained only 1.5 grams of it in each flask, the second pair contained 3.0 grams of it in each flask, and the third pair contained 4.5 grams of it in each flask. It will be seen from the analytical data that the nitrogen present in culture 1 consisted of 9.10 mg., precipitated by phospho--tungstic acid of 2.35 mg., not precipitated by this reagent, or of a total of 11.45 mg. The corresponding yields in culture 2 were 10.83 mg., 1.88 mg. and 12.71 mg. In other words, there was a maximum fixation here of nearly 8.5 mg. of nitrogen per gram of mannite consumed. In cultures 3 and 4 there were greater absolute amounts of nitrogen precipitated by phospho-tungstic acid, as well as greater absolute amounts not precipitated by it. The amounts of total nitrogen fixed here were 24.17 mg. and 23.85 mg., respectively, and the greatest maximum fixation per gram of mannite used was nearly the same here as in cultures 1 and 2. It would seem, therefore, that up to a certain point the fixation of atmospheric nitrogen is not always affected by the greater quantities of the culture medium in the flask; provided, of course, that the duration of the experiment is not too short. *On the other* hand, the yields in cultures 5 and 6, where 300 cc. of mannite were used, were proportionately much smaller than those in the other cultures. In fact, the absolute yields of total nitrogen were not very much larger than those in cultures 3 and 4, where only 200 cc. of mannite were used. The maximum yield of combined nitrogen in cultures 5 and 6 was only 5.96 mg. per gram of mannite consumed.

Series 9.

The following analyses show the gradual increase of combined nitrogen in 200 cc. cultures of *A. vinelandii.* The entire series contained thirty flasks, inoculated on February 1st. Six of these cultures were to be analysed at each of the three-day intervals until the work shall have been completed. *Two cultures in each set of six* were to be analysed for total nitrogen, two were to be treated with basic lead acetate and the nitrogen determined in both the precipitate and filtrate, and the remaining two were to be treated with phospho-tungstic acid and the nitrogen determined in the precipitate and filtrate. The respective analyses were to be made on February 4th,

7th, 10th, 13th and 16th. The amounts of nitrogen found were a follows:

				Nitrogen Fixed					
				Lead Acetate.			Phospho-Tungsti Acid.		
			Total.	Precip. mg.		Filtr. mg.	Precip. mg.		Filtr mg.
1	*A. vinelandii,*	Feb. 4.	3.47 mg.						
2	"	"	2.43 "						
			Av. 2.95						
3	"	"		2.43		0.17			
4	"	"		2.43		0.17			
				Av. 2.43	2.60	0.17			
5	"	"					2.08		0.46
6	"	"					2.26		0.69
							Av. 2.17	2.74	0.57
7	"	Feb. 7.	6.60 mg.						
8	"	"	8.51 "						
			Av. 7.55						
9	"	"		7.47		0.46			
10	"	"		8.24		0.46			
				Av. 7.85	8.31	0.46			
11	"	"					5.21		2.60
12	"	"					5.73		2.43
							Av. 5.47	7.98	2.51
13	"	Feb. 10.	11.29 mg.						
14	"	"	11.63 "						
			Av. 11.46						
15	"	"		12.50		0.69			
16	"	"		10.94		0.35			
				Av. 11.72	12.24	0.52			
17	"	"					9.65		3.30
18	"	"					9.72		2.43
							Av. 9.63	12.49	2.86
19	"	Feb 13.	12.85 mg.						
20	"	"	17.19 "						
			Av. 15.02						
21	"	"		17.71		0.69			
22	"	"		14.07		0.87			
				Av. 15.89	16.67	0.78			
23	"	"					13.20		3.65
24	"	"					14.59		3.47
							Av. 13.89	17.45	3.56
25	"	Feb. 16.	19.25 mg.						
26	"	"	17.67 "						
			Av. 18.46						
27	"	"		16.56		1.26			
28	"	"		17.67		1.42			
				Av. 17.11	18.45	1.34			
29	"	"					17.51		4.10
30	"	"					18.09		3.79
							Av. 15.80		[illegible]

The determinations of total nitrogen show a fairly constant increase *from interval to interval throughout the course of the experiment.* At the end of three days the average yield was 2.95 mg.; at the end of six days it was 11.46 mg., a further difference of 3.91 mg.; at the end of twelve days it was 15.02 mg., a difference of 3.56 mg., and at the end of fifteen days it was 18.46 mg., a difference of 3.44 mg. The final average yield represents a fixation of 6.15 mg. of nitrogen per gram of mannite consumed. The determinations of nitrogen in the lead acetate precipitate and filtrate show a greater total yield of combined nitrogen than do the direct total determinations. It was already noted in a previous report[1] that the addition of lead acetate seems to give higher results in the Kjeldahl method when used in the analysis of cultures of *A. vinelandii.* It is not at all impossible that these cultures contain a small quantity of some nitrogenous compound which is distilled off when the cultures are digested on the furnace, and that this compound is precipitable by lead acetate, or even phosphotungstic acid, as may be seen from the analytical data in the above table. Another fact deserving of notice here is the proportionate and absolute amount of nitrogen not precipitated by lead acetate *in the several cultures. At the end of three days the quantity of* nitrogen not precipitated by lead acetate was 0.17 mg.; at the end of six days it was 0.46 mg.; at the end of nine days it was 0.52 mg.; at the end of twelve days it was 0.78 mg., and at the end of fifteen days, 1.34 mg. These amounts, while small in themselves, show nevertheless that in the course of fixation by *A. vinelandii* there are formed certain quantities of organic nitrogen compounds not precipitable *by basic lead acetate, and therefore not a true protein body.* The true nature of this substance still remains to be demonstrated. Meanwhile we find that in the case of phospho-tungstic acid there are even greater quantities of nitrogen that pass into the filtrate. At the end of three days the quantity of nitrogen not precipitable by phospho-tungstic acid was 0.57 mg. At the end of six days it was already 2.51 mg.; at the end of nine days it was 2.86 mg.; at the end of twelve days it was 3.56 mg., and at the end of fifteen days it was 3.94 mg. We thus note in the cultures a steady increase in the quantity of the substances not precipitable by basic lead acetate or phospho-tungstic acid. In the latter case, however, the proportion of

[1] N. J. State Report, 1904, p. 270.

such compounds is markedly greater, as is illustrated, for instance, by the final anlyses, where the cultures treated with phospho-tungstic acid contained, on the average, 3.94 mg. of non-precipitable nitrogen in a total of 19.24 mg. Attention should also be called to the very considerable variations that occur in the duplicates. Thus, in the total determinations the amounts found at the end of three days were 3.47 mg. and 2.43 mg., respectively, or a difference of more than a milligram. A variation of almost two milligrams occurs in the second period; a variation of 4.34 mg. in the fifth interval, and a variation of 1.58 mg. in the last period. Similar variations occur also in the phospho-tungstic acid determinations.

Series 10.

Another lot of ten-day-old cultures of *A. vinelandii*, when treated for total nitrogen, for the total nitrogen in the lead acetate precipitate and filtrate, and for the total nitrogen in the lead acetate precipitate and phospho-tungstic acid precipitate and filtrate, showed on the average a somewhat larger yield of combined nitrogen in the cultures treated directly for total nitrogen.

			Nitrogen Fixed.			
			Lead Acetate.		Phospho-Tungstic Acid.	
Culture No.	Inoculation.	Total.	Precip.	Filtr.	Precip.	Filtr.
1		13.72 mg.				
2		14.20 "				
	Average	13.96 "				
3			13.57 mg.	.95 mg.		
4			11.52 "	.63 "		
5			3.16 "	.95 "	9.47 mg.	
6			3.63 "	.95 "	9.31 "	

As stated above, cultures 1 and 2 were treated for total nitrogen, and cultures 3 and 4 were treated with lead acetate, and the nitrogen determined in the precipitate and filtrate, respectively. Cultures 5 and 6 were treated with phospho-tungstic acid, filtered, lead acetate added to the filtrate, the latter again filtered, and the nitrogen determined separately in each of the two precipitates, and in the filtrate. It will be noted that the average yield in cultures 1 and 2 was 13.96 mg.; in cultures 3 and 4, 13.33 mg., and in cultures 5 and 6, 13.73 mg. It would seem, therefore, that the results in this series are not confirmatory of those in series 9, in so far as they concern the pos-

sible loss of a portion of the nitrogen substance in cultures not previously treated with lead acetate or phospho-tungstic acid. The bulk of the evidence is, however, in the other direction, and the discrepancy in the present series is due to the large yields of nitrogen in cultures 1 and 2, yields above the average in the other cultures.

Series 11.

The stimulating action of iron on the nitrogen fixation by *A. vinelandii* was already noted in a previous report.[1] A similar comparison was extended to *A. Beyerincki,* and the results presented below.

Culture No.	$Fe_2(SO_4)_3$ Added.	Inoculation.	Nitrogen Fixed.
1	None	*A. vinelandii*	11.04 mg.
2	"	"	11.83 "
3	5 mg.	"	12.46 "
4	5 "	"	13.88 "
5	None	*A. Beyerincki*	1.58 "
6	"	"	3.94 "
7	5 mg.	"	1.10 "
8	5 "	"	5.95 "

The customary 100 cc. portions of mannite were used here, and the several cultures were kept in the incubator at 27° to 28° C., from March 2d to March 14th, 1905. The analytical data show, again, the great difference in the nitrogen-fixing power of the two Azotobacter species, as well as the irregularity in the development of *A. Beyerincki.* The addition of five milligrams of ferric sulphate led to a distinct increase in the amount of nitrogen fixed by *A. vinelandii,* the maximum output being rather more than nine milligrams of combined nitrogen per gram of mannite consumed. In the case of *A. Beyerincki* the irregular results do not justify any definite conclusion.

Series 12.

When compared on the basis of equivalent quantities of iron, several compounds of the latter showed the following relations to the fixation of nitrogen by *A. vinelandii:*

[1] N. J. Station Report, 1903, p. 276.

Culture No.	Iron Added.	Nitrogen Fixed.
1	5 mg. $Fe_2(SO_4)_3$	13.95 mg.
2	" "	13.63 "
3	5 mg. $Fe_2(SO_4)_3$	13.79 "
4	" "	13.48 "
5	4.5 mg. $FeCl_3$	13.33 "
6	" "	13.63 "
7	2.3 mg. Fe_2O_3	12.54 "
8	" "	13.00 "
9	2.2 mg. Fe_3O_4	11.77 "
10	" "	12.24 "
11	50 mg. Fe_2O_3	11.30 "
12	50 mg. Fe_3O_4	11.77 "

There was but little difference in the extent to which the nitrogen fixation was favored by ferric sulphate or ferric chloride. The insoluble oxides, on the other hand, did not encourage an appreciably larger yield, and when used in amounts containing fifty milligrams of iron, if anything, to a somewhat decreased fixation. Unfortunately the addition of ferric sulphate was made by mistake, also to cultures 1 and 2, thus eliminating the standard of comparison. It should also be added here that the duration of the experiment was nineteen days, as against the twelve days in series 11, hence the somewhat larger average yield of combined nitrogen in the present series.

Series 13.

Additions of small quantities of iron slag to cultures of *A. vinelandii* and of *A. Beyerincki* failed to show any definite increase in the yields of combined nitrogen, although in the case of *A. Beyerincki* there was apparently a slight gain to be credited to the slag.

Culture No.	Iron Slag Added.	Inoculation.	Nitrogen Fixed.
1	None	*A. vinelandii*	14.83 mg.
2	1 mg.	"	14.04 "
3	2 "	"	14.99 "
4	5 "	"	14.04 "
5	None	*A. Beyerincki*	3.94 "
6	1 mg.	"	4.26 "
7	2 "	"	4.42 "
8	5 "	"	4.42 "

The maximum fixation in this series was ten milligrams of nitrogen per gram of mannite consumed for *A. vinelandii,* and slightly less than three milligrams of nitrogen for *A. Beyerincki.* The duration of the experiment was seventeen days, throughout which the cultures were kept at 27° to 28° C.

Series 14.

An attempt was made in this series to determine whether salts of manganese, cobalt and nickel, when used in small quantities, would, like those of iron, stimulate *A. vinelandii* to a more intense fixation of atmospheric nitrogen. Accordingly, eighteen 100 cc. portions of mannite in 500 cc. Jena flasks were arranged as follows:

Culture No.	Addition.	Inoculation.	Nitrogen Fixed. Precip.	Filtr.	Total.
1	None	*A. vinelandii*	11.36 mg.	2.21 mg.	13.57 mg.
2	"	"	10.41 "	2.21 "	12.62 "
3	1 mg. $MnSO_4$	"	10.57 "	1.74 "	12.31 "
4	2 " "	"	10.73 "	1.89 "	12.62 "
5	5 " "	"	11.52 "	2.21 "	13.73 "
6	10 " "	"	10.75 "	2.21 "	12.96 "
7	1 " $Fe_2(SO_4)_3$	"	9.30 "	1.89 "	11.19 "
8	2 " "	"	12.46 "	2.21 "	14.67 "
9	5 " "	"	13.41 "	1.74 "	15.15 "
10	10 " "	"	12.46 "	1.74 "	14.20 "
11	1 " $NiCl_2$	"	11.52 "	1.74 "	13.26 "
12	2 " "	"	11.36 "	2.05 "	13.41 "
13	5 " "	"	9.94 "	1.42 "	11.36 "
14	10 " "	"	7.57 "	.79 "	8.36 "
15	1 " $CoCl_2$	"	9.47 "	1.58 "	11.05 "
16	2 " "	"	.... "	... "	.... "
17	5 " "	"	.... "	... "	.... "
18	10 " "	"	.... "	... "	.... "

Manganese sulphate in the amounts added did not, on the whole, lead to any marked increase in the amount of nitrogen fixed by *A. vinelandii*; neither did it lead to any marked decrease. The corresponding additions of ferric sulphate led to a distinct increase as compared with cultures 1 to 6. The addition of nickel chlorid was followed by what may be regarded as a slight increase in cultures 11 and 12, where the amounts added were one and two milligrams, respectively. The larger amounts of nickel chlorid in cultures 13 and 14 depressed the nitrogen fixation quite perceptibly. The cobalt chlorid was even more injurious than the nickel chlorid to the development of *A. vinelandii*, since even one milligram of it reduced the yield quite appreciably. In the remaining cultures, 16, 17 and 18, where the larger quantities of cobalt were used, no nitrogen at all was fixed. It seems, therefore, that in the quantities applied manganese exerted no toxic effect; iron exerted a stimulating action, and nickel and

cobalt proved more or less toxic, particularly the last named. In practical farming there may undoubtedly be conditions where the application of small quantities of ferric chloride or sulphate, amounts not to exceed twenty-five to fifty pounds per acre, would stimulate the accumulation of nitrogen in the soil by Azotobacter species. Just at present, however, our knowledge of soil bacteria is not sufficiently intimate to permit us a systematic, practical use of the Azotobacter organisms in the nitrogen feeding of our crops.

Series 15.

The addition of potassium nitrate was found to discourage the fixation of atmospheric nitrogen by *Azotobacter vinelandii*, as the following data show:

Culture No.	Addition.	Inoculation.	Nitrogen Found.
1	10 mg. KNO_3	*A. vinelandii*	11.70 mg.
2	50 " "	"	12.66 "

The nitrate reaction was no longer given at the end of thirty-four days, indicating that the salt had been either decomposed or assimilated by the bacteria. The quantitative determinations show yields of nitrogen no greater than those obtained under the same conditions in cultures where no combined nitrogen is added. In culture 1 there was added about 1.35 mg. of nitrogen in the nitrate; hence the amount fixed was 10.35 mg. In culture 2 there was added about 6.75 mg. of nitrogen in the nitrate, and the amount fixed was therefore only 5.91 mg. Beyerinck already observed [1] that *Azotobacter chroococcum* is capable of assimilating certain amounts of nitrate. This observation, taken together with the above data, raises the interesting question as to the relation of the Azotobacter species to the soil nitrates and the nitrifying organisms. The information at hand, while still meagre, would yet lead us to believe that the Azotobacter organisms, like the symbiotic *P. radicicola* [2] would preferably cover their nitrogen requirements from the nitrates within their reach, and turn to the atmosphere for their supply of nitrogen only when the nitrates or other soluble nitrogen in the culture solution is exhausted.

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[1] Centr. f. Bact., etc., part II., vol. VII., p. 575.

[2] See Suchting, Centr. f. Bact., etc., part II., vol. VII., pp. 377, 417, 496; also Voorhees & Lipman, N. J. Stat. Bull. 180.

Series 16.

The present series is in a manner supplementary to the preceding, in that it attempts to define the relation of *A. vinelandii* to gradually increasing quantities of ammonium sulphate and peptone nitrogen in the culture solution. The flat-bottomed 500 cc. culture flasks each contained 200 cc. of mannite. The solutions were inoculated on February 11th, and kept in the incubator at 27° to 28° C. until February 27th. Analysed at the later date, they contained, respectively, the following amounts of nitrogen:

Culture No.	Inoculation.	Addition.		Nitrogen Added.	Nitrogen Fixed.
1	*A. vinelandii*	None.		None.	14.20 mg.
2	"	"		"	15.62 "
3	"	50 mg.	peptone	= 6.86 mg.	13.33 "
4	"	100 "	"	= 13.72 "	10.26 "
5	"	300 "	"	= 41.16 "	6.80 "
6	"	500 "	"	= 68.60 "	5.07 "
7	"	50 "	$(NH_4)_2SO_4$	= 10.15 "	—1.63 "
8	"	100 "	"	= 20.30 "	—2.32 "
9	"	300 "	"	= 60.90 "	—2.37 "
10	"	500 "	"	= 101.50 "	—2.38 "
11	Sterile	100 "	peptone	= 13.72 "	.... "
12	"	100 "	$(NH_4)_2SO_4$	= 20.30 "	.... "

According to the above results, there was a marked fixation of nitrogen in the cultures where peptone was added. The yields in cultures 1 and 2 were 14.20 mg. and 15.62 mg., respectively. The addition of 6.86 mg. of peptone nitrogen reduced the yield to 13.33 mg.; the addition of 13.72 mg. of peptone nitrogen reduced it to 10.26 mg.; the addition of 41.16 mg. of peptone nitrogen reduced it to 6.80 mg., and the addition of 68.60 mg. of peptone nitrogen reduced it to 5.07 mg. The addition, therefore, of large amounts of soluble organic nitrogen, while it depressed the nitrogen fixation by *A. vinelandii*, did not suspend it entirely. The results with the ammonium sulphate are rather more difficult to interpret. The analyses show throughout losses of nitrogen from the culture solution. Now, since the culture solution was made distinctly alkaline to phenolphthaleine with sodium hydroxide, it might have been expected that the sterilization in the autoclave and the prolonged exposure in the incubator would involve the loss of ammonia by volatilization. The possibility is not excluded, therefore, that there

was some fixation at least in a portion of the cultures, but that the losses were sufficiently large to more than offset the gains by fixation. The fact that the losses are practically identical in cultures 8, 9 and 10 would, however, strengthen the belief that they were due to the alkalinity of the solution. On the whole, this and the preceding experiment offer very suggestive data as to the actual relation of the nitrogen-fixing bacteria in the soil to the various forms of soil nitrogen derived from plant residues or from manurial applications.

Series 17.

Mannite is well adapted to serve as the source of food and energy for all Azotobacter species. There is, besides, a large variety of substances such as various sugars, higher alcohols, salts of the fatty acids, etc., which may be quite readily utilized by these bacteria for the same purpose. As the following analyses demonstrate, the sodium salts of acetic, propionic, buturic, and, to a slighter extent, of valerianic acid, may be used without difficulty by the Azotobacter species. Nitrogen determination were made in the precipitate and filtrate after the culture solutions were treated with phospho-tungstic acid.

Culture No.	Inoculation.	Source of Energy.	Nitrogen Fixed. Precip.	Nitrogen Fixed. Filtr.	Total.
1..	*A. vinelandii*........	Sodium acetate........	4.55 mg.	2.83 mg.	7.38 mg.
2..	"	" "	4.55 "	3.92 "	8.47 "
3..	"	Sodium propionate	5.12 "	5.18 "	10.30 "
4..	"	" "	4.87 "	6.12 "	10.99 "
5..	" +B. 36..	" "	6.12 "	2.67 "	8.79 "
6..	" " ..	" "	6.28 "	3.77 "	10.05 "
7..	"	Sodium butyrate......	5.18 "	7.03 "	12.21 "
8..	"	" "	5.49 "	5.18 "	10.67 "
9..	" +B. 36..	" "	8.63 "	3.14 "	11.77 "
10..	" " ..	" "	8.95 "	2.04 "	10.99 "
11..	"	Sodium valerate.......	... "	... "	2.67 "
12..	"	" "	... "	... "	2.20 "
13..	" +B. 36..	" "	... "	... "	2.35 "

The culture solutions used here contained the organic acids at the rate of about ten grams per liter of culture solution. Titrations against standard sodium hydroxide showed each 100 cc. of culture solution used here to contain, respectively, 1.017 gms. $C_2H_4O_2$; 0.990 gms. $C_3H_6O_2$; 0.950 gms. $C_4H_8O_2$, and 0.837 gms. $C_5H_{10}O_2$. In order to make certain that there was no decomposition of the fatty

acids in the autoclave, sterilized and unsterilized portions of the culture solutions were treated with sulphuric acid, distilled, and the distillate titrated in each case against standard sodium hydroxide. The amounts thus found were practically identical in the sterilized and unsterilized portions, showing that the fatty acids, or rather, their salts, were not decomposed on sterilization in the autoclave. The yields of combined nitrogen were high throughout, except in cultures 11, 12 and 13, where sodium valerate was the source of energy. Sodium propionate gave higher returns than did the sodium acetate, while the sodium butyrate was even superior in this respect than the sodium propionate. Additions of B. 36 did not apparently enhance the nitrogen fixation in any of these cultures; a result rather different from that obtained in the mannite solutions. It is likewise worthy to note here that the proportion of nitrogen not precipitated by phospho-tungstic acid was much larger than that in the mannite solutions. Thus in cultures 3 and 4, with sodium propionate as the source of energy, the quantities of nitrogen in the filtrate were actually larger than those in the precipitate. The same is true of culture 7 with sodium butyrate as the source of energy. A marked difference occurs also between cultures 7 and 8, and cultures 9 and 10 in the proportionate quantities of nitrogen in the phospho-tungstic acid precipitate and filtrate. In some way, the addition of B. 36, while it did not perceptibly alter the total yield of combined nitrogen, increased the proportion of nitrogen precipitable by phospho-tungstic acid.

Series 18.

The differentiation of the nitrogenous compounds formed in the Azotobacter cultures would help to explain the mechanism of nitrogen fixation, and the data submitted in the following pages were collected with this end in view. Eighteen 100 cc. portions of mannite were inoculated with *A. vinelandii,* and were analysed at the end of ten days. Determinations were made of total nitrogen in two of the cultures, while the remaining cultures had nitrogen determinations made only in the portion precipitated by varying quantities of sodium chloride, magnesium sulphate, zinc sulphate, or sodium sulphate. No attempt was made to determine the nitrogen that may have been left in the filtrates.

Culture No.	Inoculation.	Addition.	Nitrogen Fixed.
1	*A. vinelandii*	None	8.20 mg.
2	"	"	6.47 "
3	"	NaCl to 1/10 saturation	8.52 "
4	"	" " 1/5 "	6.94 "
5	"	" " 1/2 "	8.36 "
6	"	" " full "	8.36 "
7	"	$MgSO_4$ to 1/10 saturation	4.89 "
8	"	" " 1/5 "	6.15 "
9	"	" " 1/2 "	5.05 "
10	"	" " full "	7.26 "
11	"	$ZnSO_4$ to 1/10 saturation	7.89 "
12	"	" " 1/5 "	6.47 "
13	"	" " 1/2 "	5.90 "
14	"	" " full "	7.57 "
15	"	Na_2SO_4 to 1/10 saturation	4.73 "
16	"	" " 1/5 "	4.73 "
17	"	" " 1/2 "	6.31 "
18	"	" " full "	5.85 "

The above results are decidedly irregular, making it difficult to determine where the differences were due to natural variations in yield and where to the partial precipitation of the protein bodies. In so far as the sodium chloride was concerned, the one-tenth saturation was as effective as the full saturation, and the average yield of combined nitrogen was fully as great as that in cultures 1 and 2. The magnesium sulphate gave smaller yields than the sodium chloride, and the sodium sulphate gave even smaller yields than the magnesium sulphate. If nothing else, these results indicate that the bulk of combined nitrogen in the Azotobacter cultures is present in insoluble combinations removable by direct filtration.

Further Data on the Mechanism of Nitrogen-Fixation.

Agricultural bacteriologists have attempted to explain the process of nitrogen fixation by the symbiotic *P. radicicola*, or the non-symbiotic nitrogen-fixing organisms, in various ways. Several theories, some of them quite ingenious, have been advanced to demonstrate the nature of the first product of synthesis in the formation of nitrogen compounds. It has been held by some that the elementary atmospheric nitrogen is made to unite directly with the bacterial protoplasm, forming an insoluble organic compound, and that all of the nitrogen fixed was contained in the bacterial cells. Others have suggested that the fixation of nitrogen may take place in the culture

medium outside of the bacterial cells, and may be accomplished by an enzyme produced within the bacterial bodies and diffused outward. The nitrogen compounds thus formed in the culture medium could then be used by the bacteria for their development. Still others have maintained that the first product of synthesis is a soluble organic substance formed within the bacterial cells and capable of diffusing outward. Endeavors have also been made to determine whether the first product of nitrogen fixation may not be a nitrate, nitrite, or even an ammonium compound. Notwithstanding these efforts, most of them purely speculative, our knowledge of the process of nitrogen fixation is extremely limited. It is still largely shrouded in mystery and still offers a very fascinating problem to be taken up by the investigator, not alone for its scientific interest, but also for the practical significance that enlightened agriculture may attach to it. The experimental data submitted below may justly be regarded as a step in advance in the solution of this problem.

Earlier studies had led the writer to believe that the first product, or at least one of the first products, of synthesis in the process of nitrogen fixation is some amino-acid, possibly alanin (amino-propionic acid), formed within the bacterial cell. Hundreds of analyses of *Azotobacter* cultures showed a slight proportion of combined nitrogen that is not precipitated by basic lead acetate, and a still larger proportion not precipitated by phospho-tungstic acid. Cultures filtered through unglazed porcelain gave clear filtrates, which still contained appreciable quantities of combined nitrogen, as the following analyses show. The determinations were made in 25 cc. portions of the clear filtrate:

	Nitrogen Found.
1	2.35 mg.
2	2.20 "

The nitrogen in this filtrate was, for the most part, precipitated when sufficient alcohol was added to form 75 per cent. or more of the total volume, as is shown in the following determinations of nitrogen in the precipitates thus formed:

	Nitrogen Found in the Alcohol Precipitate.
1	20.74 mg.
2	19.14 "

The addition of magnesium sulphate or zinc sulphate to 100 cc. portions of this filtrate until the point of saturation was reached, caused the separation of a flocculent precipitate, which, when examined under the microscope, was found to be amorphous and free from bacterial cells. Similar determinations of nitrogen were made in 50 cc. and 500 cc. portions of another filtrate derived from a younger culture of *A. vinelandii.*

The filtrate which was collected from under a porcelain Buchner filter was found to be perfectly clear and free from bacterial cells. The amounts taken for analysis were measured off carefully and treated in the customary manner for total nitrogen:

	Nitrogen Found.
1........In 50 cc. of the filtrate....................	.80 mg.
2........" " " " " "	.80 "
3........" 500 " " " "	7.69 "
4........" " " " " "	8.00 "

It was quite clear, in view of the above, that in the course of nitrogen fixation by *A. vinelandii,* there is formed a soluble nitrogenous substance, which is not an essential part of the bacterial cell, and which diffuses outward into the surrounding medium. This compound may be an albumose, but not necessarily in itself the first product of synthesis. At any rate, it is not precipitated from the clear filtrate by the addition of a small quantity of acetic acid nor by boiling. It is largely precipitated by phospho-tungstic acid, by basic lead acetate, and to some extent also by tannic acid, as may be seen from the following determinations of nitrogen in 100 cc. portions of the clear filtrate treated as indicated.

Treatment.	Nitrogen in Precip.	Nitrogen in Filtr.	Total.
1......Acidified with a few drops of acetic acid....	...	4.24	4.24
2......Boiled for several minutes................	...	4.24	4.24
3...... 5 cc. phospho-tungstic acid[1]................	3.20	1.60	4.80
4......15 " " "[2]................	3.20	1.28	4.48
5......Lead acetate	3.61	1.10	4.71
6......Tannic acid, 10 gms......................	1.60	(not determined).	

[1] Prepared according to Mallet, Bull. 54, Div. of Chemistry, U. S. Dept. of Agriculture, p. 19.

[2] Prepared according to Osborne and Harris, Jour. Amer. Chem. Soc., vol. XXV. (1903), p. 331.

It will be seen from the above that of the soluble nitrogenous substance present in the filtrate from the Buchner funnel, a considerable proportion is not precipitated by lead acetate, and even a larger proportion is not precipitated by phospho-tungstic acid. The tannic acid precipitated only about a third of the total nitrogen present in the filtrate.

All of these data, however incomplete in themselves, furnish valuable hints as to the actual reactions occurring in the process of nitrogen fixation. The fact that acetic, propionic and buturic acids, all among the first members of the fatty acid series, are quite readily used by the Azotobacter species as their source of food and energy; that lactic acid is likewise readily used by them; that the hexoses and their alcohol derivatives may readily undergo a lactic fermentation, etc., may indicate the course of synthesis as passing through the oxy-acids, amino-acids, peptides, poly-peptides, etc. Investigations in this direction may yield the desired information.

Meanwhile it would not be out of place to report here the examination of the crude, dried Azotobacter membranes according to Hausmann's method as used by Osborne and Harris.[1] For the sake of comparison, a number of analyses were made according to this method of casein and of egg albumen. The following analytical results were obtained:

	Nitrogen As NH_3. Per cent.	Basic Nitrogen. Per cent.	Non-Basic Nitrogen. Per cent.	Nitrogen in the Magnesium Oxide Precipitate. Per cent.	Total Nitrogen. Per cent.
Casein	1.45	3.07	8.86	0.25	13.63
"	1.45	3.02	8.98	0.18	13.63
Ovalbumin	1.17	2.94	7.76	0.17	12.24
"	1.13	2.91	7.83	0.17	12.24
Azotobacter membrane	.98	2.76	6.29	0.42	10.45

The casein and albumin used in these determinations were not pure. When recalculated on the basis of 15.62 per cent. of nitrogen for casein [2] and of 17.97 per cent. for the Azotobacter membrane, the results become:

[1] 1. c.

[2] Osborne and Harris, 1. c., p. 346.

	Nitrogen As NH_3. Per cent.	Basic Nitrogen. Per cent.	Non-Basic Nitrogen. Per cent.	Nitrogen in the Magnesium Oxide Precipitate. Per cent.	Total Nitrogen. Per cent.
Casein	1.66	3.52	10.15	.29	15.62
"	1.66	3.46	10.29	.21	15.62
" (Osborne and Harris)	1.65	3.46	....	..	....
" " "	1.58	3.53	10.30	.21	15.62
Azotobacter membrane	1.68	4.75	10.82	.72	17.97
Legumin [1]	1.69	5.18	10.92	.17	17.97

It will be noted that the composition of the Azotobacter proteid would quite well coincide with that of legumin when calculated on the basis of the same nitrogen content. The proportions of ammonia, of basic and non-basic nitrogen in the two substances run parallel to one another, with the exception of that in the magnesium oxide precipitate. The difference could easily be accounted for by the presence in the Azotobacter membrane of non-nitrogenous substances, which would naturally increase the proportion of the humic nitrogen.

[1] l. c., p. 349.

REPORT OF THE HORTICULTURIST.

REPORT OF THE HORTICULTURIST.

G. F. WARREN.

Eight months of the Experiment Station year had passed when I took charge of the Department of Horticulture; therefore, I have seen only a little of the latter end of the season's experiments on the Station grounds. The larger part of the work has been a continuation of experiments started a few years ago, and has been kept up by Miss Voorhees, the assistant in horticulture, who has prepared the report on this work.

The short time that I have been connected with the Station has been fully occupied with plans for greenhouse work and for experiments for next year. What time has been available has been devoted to a study of the peach orchards of the State and of the possibilities of the renewal of the peach industry. A little time has also been given to other fruit interests and to asparagus. Eighty peach orchards have been carefully examined and records made of the pruning, tillage, fertilization, spraying, insect and fungous enemies, soil, drainage, yields, markets, prices, etc. Thirty-six orchards of apples and pears have been similarly studied. A much larger number of other orchards have been examined, but careful records have been made of the above number. Summaries of the peach investigation will be published in bulletin form and will probably appear before this report. A repetition of a few of the conclusions to which these statistics point may not be out of place here. The detailed report will be given in the bulletin.

FIELD NOTES ON PEACH GROWING.

That the peach industry of the State has been all but exterminated is a painful fact that is too well known to the peach growers to need to be repeated. One town that formerly shipped train loads each day,

now ships three or four cars per week. The industry is not equally damaged in all neighborhoods, but the story has been much the same. The immediate cause has been the San José scale, but other important causes have contributed to the result.

Spraying Peach Trees.—The time has come when any man who desires to do so can raise all the peaches that he cares to grow, in spite of the scale. The united and persistent efforts of the Experiment Station and the farmer have solved the scale problem almost as nearly as the potato bug problem has been solved—both can now be controlled. Better methods will doubtless be worked out, but the present methods make a renewed and profitable peach industry possible. It is a pleasure to hear farmers who have succeeded so well that they can say, as several have said: "God bless the San José scale; we can raise peaches in spite of it, and get so much better prices that the extra work is many times paid for." Certain it is that they are succeeding, for there are a goodly number of orchards in which the scale is kept entirely under control.

One way that this has been done by a number of growers is to spray every year with lime, salt and sulphur, beginning the first spring after planting and *never missing a year for any cause.*

Why spray before scale appears? Because not one man in ten can tell when it does first appear. It is manifestly impossible to examine every tree every year. Even if this were possible, the scale might be overlooked. It is likely to be on the limb not examined. Then before fall the tree is "smeared" with scale. Of the eighty orchards examined, just one that was old enough to bear (that is, at least three years old last spring) had been known to have scale and had none that I could find, but I have no doubt that this one had scale on it. I certainly would not dare to say that the top of some other tree that I did not see had none. No spraying, however effective, can make it safe to let trees go a year. The scale may appear to be all killed, but there are almost certain to be enough hidden away somewhere to overrun the tree next year. In short, it can never be exterminated; it can only be controlled. In the orchards examined, a number have followed the above practice. The only failures have resulted from waiting till trees were nearly dead with scale and from a perfunctory spraying. Every tree should be sprayed from every direction and every particle of bark from the ground to the tip of the uttermost twig must be covered. Many growers go through the orchard four times and so

spray each tree on all four sides. However it is done, the entire tree must be covered.

While no failures have been found from one treatment every year from the time of setting, in some cases it will probably be necessary to make a second application of some spray in the fall or winter, but the orchard evidence seems to indicate that this will not often be necessary if thorough, careful spraying is done every year. To get old, badly-infested trees into shape requires more labor. In such a case the bulletins by the State Entomologist should be consulted. There are other ways of controlling the scale and other times for spraying. Some of the soluble oils are certainly very promising, as indicated by the report of the Station Entomologist. I am speaking of this spray because it is very much more than an entomological question, as will be seen further on.

One reason for applying this spray before scale appears is given above, but there is another extremely important reason. The lime, salt and sulphur spray is an excellent fungicide, almost equal to Bordeaux mixture. It is worth its cost even if there is no scale. One application of it just before the buds open will almost invariably control the leaf curl, and will have a beneficial effect on the many other fungi that attack the peach. The contrast in foliage between trees thus treated and untreated ones has been very striking in many orchards. Fall and winter applications do some good in controlling fungi, but the applications just before the buds swell is much more effective. The scale has served to distract attention from some of the other very important peach troubles.

Leaf Curl (*Exoascus deformans*).—This disease has sometimes been called the early blight by growers. Many farmers report that it was very severe in 1904, frequently causing all the leaves to fall and ruining the crop. It is particularly severe on the Elberta. In some of the orchards examined it caused the loss of the 1904 crop and so damaged the trees as to reduce greatly the 1905 crop. There was rather less curl this year, but a number of orchards were examined that had lost most of their leaves because of it, and the damage has frequently been very much more than enough to pay for spraying. Fortunately this is one of the easiest plant diseases to control, one thorough application of Bordeaux mixture just before the buds open being almost always sufficient. Several growers in Sussex county have begun to spray regularly for this disease. In controlling it, lime, salt and sulphur is almost as effective as Bordeaux mixture.

Brown Rot (*Monilia fructigena*).—Damage from this disease was very severe during the past summer in many orchards. This fungus not only attacks the peach, but frequently attacks the blossoms and twigs. Some of the failures to set fruit that are attributed to the weather are due to the complete destruction of the blossoms by this fungus. The treatment for this is not as simple or as effective as that for leaf curl, but Experiment Station work and experience of peach-growers in large orchards, particularly in Georgia, have shown that three to five sprayings prevent enough of the rot, so that there is a good profit in giving them. Most of the commercial growers in Georgia are said to spray from three to five times for the rot.

Scab (*Cladosporium carpophilum*).—This disease causes the small brown spots on the peach and sometimes causes the fruit to crack, so that other fungi can readily obtain a foothold and increase the damage. In severe cases it sometimes stunts one side of the peach, so that the fruit is one-sided. Unlike most fungi, it seems to thrive best in sunlight. The shaded side of the peach is not often affected. This disease is so common that it frequently passes as a part of the peach itself. Its almost universal occurrence is shown by the fact that nearly every exhibit of peaches at the Trenton Inter-State Fair was also an exhibit of this disease. Spraying as for the brown rot has been shown to be fairly effective in controlling it.

Shot-hole Fungus (*Phyllostica*, Sp.).—This disease was very serious in many of the orchards examined, causing a large part of the leaves to drop during the summer and injuring many of those that were left. It causes small, brownish-red spots on the leaves, that sometimes drop out, leaving the shot-hole effect. It was very much more serious in neglected orchards than in those that were well fertilized and tilled. Farmers sometimes refer to it as the "late blight."

These four fungous enemies were the most serious ones found in orchards this summer, but there were many other less serious fungi that live at the expense of the peach. The minimum spraying that any good peach-grower should do is to give one good application of a good fungicide every spring before the buds open. Bordeaux is a little the best, but since the advent of the scale, lime, salt and sulphur is the one to use. There is little doubt but that about three later applications of Bordeaux will be repaid; at any rate, it is well worth a trial on part of the orchard. The complete report will discuss these later sprayings more fully.

Yellows.—The damage from this was not as serious as had been expected. Many trees that are said to have the yellows do not have it, but are being killed by borers, sod or neglect in other ways. A good conservative policy for a peach-grower is to give the trees good, all around care, so that there is no apparent reasons for a tree to fail and then to remove every sick tree. If he really has a good orchard, his pride in keeping things up will generally cause him to do this.

Borers.—The damages from borers were enormous in many of the orchards examined. In a very large number of orchards borers are entirely ignored or are treated with some concoction that has no effect. No method of keeping them out has ever been discovered that is wholly effective. Some methods will help, but every method must be *supplemented by digging out—"worming." The best practice is* to remove them in the fall and again in the spring. A careful man, with a knife and wire, will do this rapidly and without serious injury to the trees.

Tillage.—There is quite a diverging in methods of tillage. Some till in the spring as early as the ground is fit to plow, and keep the ground well tilled until the middle of July or first of August. Others wait until the corn is planted before caring for the peach orchard, sometimes letting it go until the middle of June, or even later. If a man is a peach-grower, the former practice is the proper one; if corn is his crop and he does not care for peaches, then it may be all right for the peaches to be made secondary, or perhaps it would be better to grow only corn. Sometimes the reason for leaving the peach orchard is fear of frosts or of making the fruit drop. There does not seem to be any real evidence back of these theories. The wisest practice is undoubtedly that of many of the best growers, who begin to till early and stop early—earlier in wet than in dry seasons.

Extensive planting of peaches is certain to commence soon. Already many men have ceased to fear the scale and are planting; many more will follow in the next few years. Those who give these young trees good care certainly have good prospects for a profitable investment. Those who do not give this care are as certain to fail. We cannot too much emphasize the importance of breaking away from some of the old traditions of the time when peaches grew well with little care (if there ever was such a time). We must spray. It will not pay to go to this expense and let the borers kill the trees. Having sprayed and taken out the borers, it will not pay to let the trees go half-starved

from want of plant-food or tillage. In short, the new peach-grower will give better care in every way, and he will usually get paid in proportion as he gives this thorough, all around care.

APPLES.

There are many apple orchards in the State, but the majority of them are neglected, old trees. In many cases their chief value is to furnish shade for the cows that pasture among them and to furnish a few apples for home use. These old orchards are fast disappearing. Some are still worth renovating. Many merely serve as breeding places for insect pests. If they are not worth renovating they should be cut down, so as not to be a menace to the good orchards. There are also quite a number of orchards that receive almost perfect care, but they are few of the total number.

While connected with the Cornell Experiment Station during the past two years, it was the writer's privilege to make a careful orchard survey of over 1,000 apple orchards in Western New York, the reports of which are given in Cornell Bulletins Nos. 226 and 229. The first feature in Warren and Sussex counties that attracted my attention was the soil, large areas of which are identical with soils in Wayne county, New York. It happens that the geologist who worked with me in New York, Mr. W. E. McCourt, worked for the New Jersey State Geological Survey last summer, and spent some time in Warren and Sussex counties. He corroborates my conclusion and adds that these soils have the same geological formation as those in this famous apple region in New York. The climate of this region is also very similar to that of Northwestern New Jersey. Certainly no region that I have yet seen is better suited for apples than these counties in Northwestern New Jersey. Nature has done her part well. All that is necessary is to plant apple trees and take care of them. The orchards that are now planted are giving about the same return as orchards similarly treated in Western New York.

The average price per barrel paid to growers in Orleans county, New York, has been: 1900, $1.41; 1901, $3.15; 1902, $1.79; 1903, $1.85; 1904, $1.46 (includes only those sold before January 25th).

This is the average of all apples sold in barrels—culls, windfalls and "seconds," as well as "firsts." It is an average from good and poor orchards, just as they come.

They show marked contrast with average prices paid in New Jersey. There are two reasons for the difference. The emphatic one is the difference in value of the fruit. A second reason is that individual orchards and the orchard area around one shipping point in New Jersey are usually too small to attract the larger buyers. In Orleans county, New York, 68 per cent. of the area has been tilled at least a part of the last five years, 88 per cent. is usually sprayed, 61 per cent. was sprayed in 1904, 91 per cent. receives some barnyard manure. Pruning is done in proportion. The apples in Northwestern New Jersey bring about all that they are worth, and nearly as much as apples that are equally scabby and wormy in Orleans county. There are many orchards that would pay well for renovation and care. Such care means pruning, spraying, manure and usually tillage, at least with a disc harrow—four things that few of these orchards receive. One of the reasons for neglect is that in many cases the orchard is too small to attract attention, but there are quite a few five to ten-acre orchards, and some smaller ones, that will pay for good care.

With an ideal apple soil that can be had at from $10 to $50 per acre, good climate and nearness to market, there are certainly good opportunities for the modern apple-grower in these counties.

PEARS.

The production of Keiffer pears, which had such an impetus a few years ago, seems to be on the decline. Many of these orchards are now entirely neglected. Farmers say that the Kieffer is not like it used to be. One of the troubles is the prevalence of leaf spot, or leaf blight, and this same fungus on the fruit. Many orchards were defoliated early in the fall and had their fruit badly damaged. In the cases carefully examined the trouble was due to the fungus *Entomosporium maculatum*, which is the common cause of leaf spot and fruit spot. This can be readily controlled by use of Bordeaux mixture. It will pay to spray even a Keiffer pear. The spraying costs only a few cents per tree.

The blight has been quite serious on many Bartlett trees and has done considerable damage in some Keiffer orchards. The most effective method of controlling this is to avoid too rank growth by limiting the amount of nitrogen and humus in the soil. Also remove all affected limbs so far as possible.

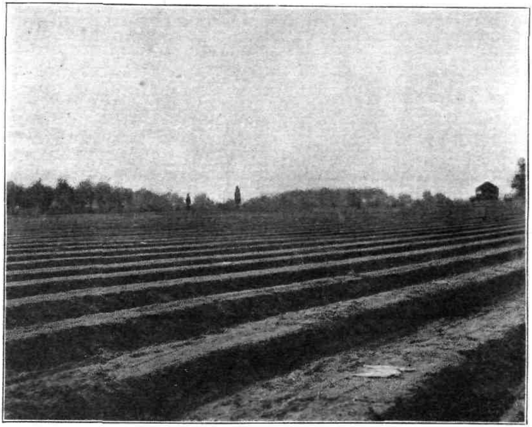
ASPARAGUS.

About the middle of May a few days were spent in the State in the asparagras districts of Monmouth and Gloucester counties. In the former "white grass" is grown, in the latter "green grass." Figure shows a typical bed in Monmouth county just after cutting. As will be seen, practically everything in sight is cut. The beds are kept hilled about eight to ten inches high during the cutting season. Figure shows a typical field in Gloucester county, also just after the cutting. The Philadelphia and Boston markets are said to favor the green asparagus. However, both kinds are shipped to Boston and New York. In the cases examined shipments from the two districts, of equal quantity, were bringing about the same prices. The hilled culture has very marked advantages in lessening the damage from the beetle and in many other ways.

The asparagus beetle is responsible for more damage than is sometimes supposed. In one bed cutting green asparagus, a close examination was made of a large number of hills. This bed was an old one and contained large numbers of small stalks. It had an average of three beetles on every stalk. Needless to say, the price of the product was much reduced after it had supported these for a day or two before being cut.

In all beds there are some more or less crooked stalks. Most of these have the top inch or two bent over. This is usually due to some injury of the tender tip, so that growth is checked on one side. It may be caused by a sandstorm, by injury in breaking through a hard crust of soil or by any other means that hurts one side of the growing tip. In most of the cases seen it was apparently due to the attacks of the beetle.

From one bed cutting white asparagus, the owner was putting up three grades—firsts, seconds and "crooks." The latter were the same as the first, except that they were crooked. The grower's record of six days' cutting from this bed showed 195 bunches of "crooks" and 1,769 bunches of firsts and seconds, or a little over 11 per cent. were "crooks." This represents a considerable loss, as they cost the grower as much as firsts, but sold for about half as much. In cases of such severe damage as this, particularly in the former case, it would seem advisable to consider means of controlling the beetle.



Asparagus Bed in Monmouth County, just After Cutting, Showing the Method of Growing "White Grass."

Asparagus Bed in Gloucester County, Showing the Method of Growing "Green Grass."

The great enemy of the asparagus grower is the rust. Cultural methods have considerable influence on the development of this disease, the more vigorous plants of the same variety being more resistant. On the Station grounds the manured plots have rusted very much less than those receiving commercial fertilizers. The plants receiving the largest amount of fertilizer have rusted slightly less than those receiving smaller amounts. The irrigated plants have rusted slightly less than those not irrigated.

There is a great difference in the susceptibility of different varieties. The Palmetto and French Argenteuil are the rust-resisting ones, and are the only ones that are profitable for planting. Perhaps I should say Palmetto or French Giant Argenteuil, as there is considerable doubt as to whether these are two distinct varieties.

Some growers have failed in getting the Palmetto or French variety when these have been ordered. There is also a great variation in seed obtained from different sources. Mr. John G. Whitall, of Woodbury, sends in a typical report on this difficulty. In writing of a bed belonging to one of his neighbors, he makes the following statement: "The bed had French Argenteuil that came from three sources. One, after three years, appears immune from rust. I have myself observed it closely for two years, and there has been no rust worth speaking of on it. There is one row across the field surrounded by others that are badly rusted, but this still shows the deep green [November 1st, 1905]. The owner says that it does not grow quite as large as Palmetto, but he has great hopes for it. No. 2 French Argenteuil rusts considerably —about like Palmetto, which the owner thinks it is. No. 3 Argenteuil rusts very badly."

There is also a great difference between plants that are all from the same source. On the Station grounds there are badly-rusted Palmetto plants and other plants that are very little rusted. We have saved seed from the rust-resisting plants and have received seed from a number of growers from good plants that were little affected. This seed will be planted next spring, together with seed from other sources, in the hope of developing a still more rust-resisting strain of Palmetto.

When we consider the great difference between plants in the same bed and between seed from different sources, together with the reported difficulty of getting true Palmetto, there can be no doubt but that the best possible thing for the grower to do is to save seed from his best plants that are rust-resisting. There is not the least doubt

but that he can in this way, in time, secure a more resistant bed of plants. Several growers have already started this practice. Mr. H. W. Ridgway tells me that he began selecting this way nearly five years ago. Those who do not have good plants of their own will be well repaid if they secure their seed from a grower who does have good plants. In thus selecting seed it is important that it be selected from good beds as well as from good plants in these beds. In fact, it is just as important that the bed be good as that the individual plant be good. Asparagus has male and female plants. One plant furnishes the pollen and another plant bears the seed. If a good seed-bearing plant is surrounded by none but poor plants, the seed from it will be a "half-breed," having half the "blood" of some poor plant in it. If such a *plant is surrounded by good plants, the seed will be descended from* good parents on both sides. In selecting seed we see only one of the parents; the other parent, whose part in the seed-production is just *as important, is one of the surrounding plants; it is therefore essential* that these be good. It will pay to start a new asparagus bed from seed that comes from a productive, rust-resisting bed and that is selected from the best and most resistant plants in this bed. If skeptical about the results, then plant a few rows of ordinary plants in the center of the new bed for comparison.

REPORT OF ASSISTANT IN HORTICULTURE.

REPORT OF ASSISTANT IN HORTICULTURE.

JENNIE A. VOORHEES.

Since upon the permanent plots there are three main experiments, namely, fertilizer, irrigation and variety tests, the general results will be considered under each head, and the tables inserted with the discussion in detail of varieties and plots.

Along with the regular experimental work a daily record of temperatures and rainfall has been kept, of which the latter statistics are published (Table No. 1 and Table No. 2). From reference to these tables it will be seen that during the summer a severe drought occurred, necessitating frequent and heavy irrigation. From November, 1904, up to the last of July, we received fifteen inches less than the normal rainfall for this section—only one month (March) shows the normal amount. The effects of the dry weather did not begin to show seriously until the early part of June.

The low temperature during the winter was also exceptional for this section. But on account of the steadiness of the cold and the almost continual covering of snow upon the ground, little winter-killing resulted. Various blackberries, left weak from severe killing the previous winter, were slightly injured. The break-up of the winter was late and so gradual that no loss of fruit occurred from frosted blossoms.

TABLE No. 1.

Daily and Monthly Precipitation, in Inches, at the College Farm, for the Year Ending October 31st, 1905.

DATE.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.
1					0.11			0.23	T	T		
2			0.03	0.02				0.17	0.26		0.11	
3		T	0.10						0.49		1.64	0.43
4	0.04		0.09		0.12	0.05					1.16	
5		0.20			0.28	1.07						
6		0.04	0.15	0.68	0.30	0.38		0.28	T	0.29		
7			1.11		0.69			0.26				
8		T						0.07		0.33		
9	0.61			0.27						0.11		
10	T	0.03				0.06				0.04		
11	0.58	T	T			0.24	T		0.10		0.25	0.14
12		0.24	0.73	0.14		0.24	0.34	0.27	0.12		0.40	0.56
13	1.08	0.10		0.85					T	0.52		
14	0.26						0.05			0.07		
15				T		0.05	T			0.95		
16						T	0.43			1.18		
17		0.04					0.06				0.21	
18		0.32				0.07	0.49				0.52	0.04
19					0.35							0.08
20		T		0.18	0.30	T					0.03	1.55
21			T		0.98	0.15		0.04				
22			T		0.10	0.06		0.34				
23							0.01	0.10	0.52			
24		0.11	0.05					0.07				
25		0.22	0.35		0.50			T	0.11	1.28		0.06
26		0.05	0.04						0.05			0.13
27	T	0.58			0.27	0.42						
28		0.14		T			0.45					
29						0.04			0.42	0.09		
30	0.13		0.02		0.07				1.46	0.10		
31							T		0.70			
Total	2.70	2.07	2.67	2.14	4.02	2.83	1.83	1.83	4.23	4.96	4.32	2.99
Normal	3.74	3.66	3.82	3.64	3.77	3.68	4.02	3.80	4.92	4.93	3.94	3.45

TABLE No. 2.

Monthly Precipitation, in Inches, Since January 1st, 1896.

YEAR.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	Yearly total.
1896	....	....	1.68	5.85	5.92	1.41	8.70	4.93	4.87	2.42	4.81	1.62	86.71
1897	2.95	1.59	2.89	2.77	2.47	8.47	6.45	2.50	12.84	8.81	2.10	1.59	44.93
1898	4.52	5.09	8.92	8.49	8.09	4.17	7.86	1.13	8.91	6.44	1.46	5.80	50.88
1899	*7.14*	*8.16*	*4.88*	*5.87*	*6.68*	*1.50*	*2.04*	*8.54*	*6.32*	*8.45*	*7.80*	*2.96*	*54.79*
1900	4.11	2.06	4.35	5.30	8.40	2.88	5.58	2.64	6.94	2.24	8.80	8.58	45.83
1901	4.27	2.82	2.01	0.76	5.19	7.89	5.01	0.81	9.12	8.90	1.86	1.99	49.68
1902	2.21	7.80	2.70	6.46	8.79	8.09	1.51	6.08	8.42	6.29	5.25	7.76	55.86
1903	1.58	6.83	8.84	4.61	4.74	4.57	0.29	7.85	5.07	5.97	8.69	7.16	55.70
1904	1.21	8.58	8.11	2.52	2.88	8.49	2.79	2.50	7.99	18.01	5.09	5.80	58.42
1905	2.70	2.07	2.67	2.14	4.02	2.83	1.88	1.88	4.28	4 96	4.82	2.99	36.59
Average	*8.41*	*4.10*	*3.15*	*3.92*	*4.16*	*8.48*	*3.70*	*8.33*	*6.42*	*5.84*	*8.96*	*4.12*	*48.43*
Normal for section	8.74	8.66	3.82	8.64	8.77	3.68	4.02	8.80	4.92	4.98	8.94	8.45	47.87

During January rains removed the snow long enough to admit the application of fertilizers. Since that time the various cultural duties, under main heads, have been performed on the following dates:

1. *Pruning*—

Mar.	6–14.	Small fruits.
"	18.	Peaches.
"	20.	Plums.
"	23.	Cherries.
"	27.	Pears (Dwarf).
"	28.	Pears (Standard).
April	1.	Apples.
July	21.	Dead wood removed from orchards.
Oct.	11.	Several trees removed (treated under plot reports).

2. Sowing fertilizer and spreading manure according to scheme (Tables III. and IV.).

(*a*) Small fruits and asparagus.

Jan.	19.	Bone and potash; bone, potash and acid phosphate.
Mar.	16.	Manure.
April	11.	Complete fertilizer.
June	22.	Nitrate of soda.

(*b*) Orchards.

April	27.	Nitrate of soda.
"	29.	Bone, potash, acid phosphate.

3. Cultivation—

(a) Small fruits and asparagus.

April 1.	Plowed asparagus—shallow.
" 12.	Plowed fruits—set new strawberry bed.
" 15.	Cultivated fruits.
" 20.	Cultivated asparagus and covered crowns—ridges seven inches high.
Aug. 24.	Last cultivation—up to this time small fruits and asparagus had been cultivated every ten days or two weeks.

(b) Orchards.

May 20.	Plowed.
June 3.	Cultivated.
July 20.	Cultivated.
Aug. 14.	Cultivated.
" 18.	Sowed to crimson clover.

4. Irrigation—

June 27–29.	Blackberries	2	inches.
	Raspberries	2	"
July 1, 2, 3.	Asparagus	1.75	"
" 6–7.	Strawberries	1.75	"
" 10–11.	Currants and Gooseberries,	2	" each.
" 13, 14.	Raspberries	2	"
" 15–17.	Blackberries	1.5	"
" 20, 21.	Strawberries	2	"
" 27.	Blackberries	1.3	"
" 28, 29.	Asparagus	2.7	"
" 30.	Pears (Dwarf)	1.9	"

The arrangement of varieties of fruits and asparagus, and of the plots of the same, are as follows:

The out-of-door plots contain five acres, of which one and one-thirty-sixth acres are devoted to fertilizer, irrigation and variety of tests of asparagus and the small fruits—blackberries, raspberries, gooseberries, currants and strawberries. The plots in each case are arranged in two blocks, and are numbered thus:

Block I., Plots 1, 2, 3, 4.
" II., " 5, 6, 7, 8.

In Block I. there are six rows, 160 feet long, each row a different variety. Block II., duplicating this, is irrigated, so that in testing the effect of different fertilizers there will be in each case two plots identical in treatment, size, number of rows and in varieties, differentiated only by irrigation. There are only four varieties and six plots of gooseberries and currants, but the whole is arranged on the same general plan. There are four additional varieties of asparagus in four

rows, running through the fertilizer experiment, but not duplicated for irrigation.

The fertilizers applied to these blocks are given in Table No. 3.

TABLE 3.

Showing Fertilizers, Amounts and Time Applied to the Different Plots, Asparagus and Small Fruits.

KIND OF FRUIT OR VEGETABLE.	Plots 1 and 5.	Plots 2 and 6.	Plots 3 and 7.	Plots 4 and 8.
Asparagus	20 ts. *yard manure *applied in fall.*	1,000 lbs. complete† *applied in spring.*	1000 lbs. complete applied in spring; 300 lbs. bone and potash ‡ applied in fall.	1,000 lbs. complete applied in spring; 300 lbs. bone and potash applied in fall; 200 lbs. nitrate soda applied when cutting ended.
Blackberries	20 ts. yard manure applied in fall.	500 lbs. complete applied in spring.	500 lbs complete applied in spring; 300 lbs. bone and potash applied in fall.	500 lbs complete applied in spring; 309 lbs. bone and potash applied in fall; 200 lbs nitrate soda applied after blossoming.
Raspberries	20 ts. yard manure applied in fall.	500 lbs. complete applied in spring.	500 lbs. complete applied in spring; 300 lbs. bone and potash applied in fall.	500 lbs complete applied in spring; 300 lbs. bone and potash applied in fall; 200 lbs. nitrate soda applied after blossoming.
Strawberries	500 lbs. complete applied in spring.	500 lbs. complete applied in spring; 150 lbs. nitrate soda applied after blossoming.	500 lbs. B. P. and A. P.§ applied in spring; 150 lbs nitrate soda applied after blossoming.	500 lbs. B. P and A. P. applied in spring.
	Plots 1 and 4.	Plots 2 and 5.	Plots 3 and 6.	
Currants	20 ts. yard manure applied in fall.	500 lbs. B. P. and A. P. applied in fall.	500 lbs B. P. and A. P. applied in fall; 150 lbs. nitrate soda applied after blossoming.	
Gooseberries	20 ts. yard manure applied in fall.	500 lbs. B. P. and A. P. applied in fall.	500 lbs. B. P. and A. P. applied in fall; 150 lbs. nitrate soda applied after blossoming.	

*The quantities of manure or fertilizer given are in every case the amounts per acre to be applied.

† Complete Fertilizer—a mixture of the best forms of fertilizing constituents, analyzing nitrogen, 4.5 per cent.; phosphoric acid (available), 7.7 per cent., and potash, 12.8 per cent.

‡ An even mixture of ground bone and muriate of potash.

§ An even mixture of ground bone, muriate of potash and acid phosphate.

To show the arrangement of the orchards containing the fruits—plums; cherries; pears, dwarf, dwarf by pruning, and standard; apples and peaches—each row a different variety, may be numbered thus: Trees 1 and 2, plot 1; tree 3, an odd variety; trees 4 and 5, plot 2; tree 6, an odd variety, etc. Thus each plot contains two trees of each row—that is, of each variety, and is separated from the next plot by a line of trees of odd varieties to prevent interfeeding. In spreading the fertilizers on the different plots, the dividing line in each case is a line little over half way to those trees. These odd varieties are not comparable with each other, except in the case of the row between adjacent plots. Thus all trees numbered 3 may be compared, and also those numbered 6, but not those numbered 3 with those numbered 6.

The scheme of fertilizers for the orchards is given in Table No. 4.

TABLE 4.

Showing Fertilizer, Amounts and Time of Application for the Various Fruit Trees.

KIND OF FRUIT.	Plot 1.	Plot 2.	Plot 3.	Plot 4.
Apples	Nothing.	500 lbs ‖ B. P. and A. P.† applied in spring.	500 lbs. B. P and A. P. applied in spring.	
Peaches	Nothing.	500 lbs B. P. and A. P. applied in spring.	500 lbs. B. P. and A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.	500 lbs. P and A. P.‡ applied in spring; 150 lbs. nitrate soda applied early and turned under.
Standard Pears	Nothing.	500 lbs B. P. and A. P. applied in spring.	500 lbs. B. P. and A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.	
	Plots 1 and 4.*	Plots 2 and 5.	Plots 3 and 6.	
Dwarf Pears	Nothing.	500 lbs. B. P. and A P. applied in spring.	500 lbs. B. P. and A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.	
	Plots 1 and 3 *	Plots 2 and 4.		
Plums, Cherries	500 lbs. B. P. and A. P. applied in spring.	500 lbs. B. P. and A. P applied in spring; 150 lbs. nitrate soda applied early and turned under.		

‖ The quantities of fertilizers given are in all cases the amount per acre to be applied.

† An even mixture of ground bone, muriate of potash and acid phosphate.

‡ A mixture of muriate of potash and acid phosphate in the proportion of 1 lb. of the former to 2 lbs. of the latter.

*Plots 1, 2 and 3 Dwarf Pears and 1 and 2 Plums and Cherries are [illegible]

ASPARAGUS AND SMALL FRUITS.

Fertilizers, Asparagus, Blackberries and Raspberries.

The experiments with fertilizers on the small fruits and asparagus resolve themselves this year into a demonstration of the greater value of manure in comparison with commercial fertilizer when applied in the amounts shown in Table No. 3. In the averages of the four duplicate plots we find that manure leads in all cases, both in total and early yield. In the series with complete fertilizer as basis of application of commercial stuffs, this mixture alone stands second quite as uniformly. While it produced on the whole only 19 per cent. less than manure, the approximate cost, if both materials must be purchased, is, on asparagus, 50 per cent. less, and on raspberries and blackberries, 75 per cent. less. Of the other two treatments, neither stands decisively as third or fourth in importance. Complete fertilizer, with bone and potash, stands third in total and early yields on asparagus, in total yield on raspberries and in early yield on blackberries. The fourth places in these cases are held by this combination, with the addition of nitrate of soda, as also the remaining third places. Therefore, on the whole, this addition of nitrate of soda has been of little consequence, but has appreciably increased the cost.

CURRANTS AND GOOSEBERRIES.

In this series manure was applied to the first plot; bone, potash and acid phosphate were applied to the second plot, and these, with the addition of nitrate of soda, to the third. The latter combination stood next to manure in yield, except in the case of currants, where irrigation caused such an increase on the second plot to make this stand above the third in the average. This is, however, an irregularity not in accordance with the average of the seven crops harvested.

In other cases where the order of importance this year does not coincide with the general returns, a special note of it will be made in the discussion of the separate plots, with direct regard for the tables of actual yields.

Irrigation.—Turning now to irrigation, we find, on the whole, that it has been effective. It has given an increase in every case except on asparagus. The differences in each case are as follows:

Asparagus—Decrease	8.0	per cent.
Blackberries—Increase	32.0	"
Raspberries— "	14.0	"
Currants— "	1.7	"
Gooseberries— "	0.9	"

The small increase upon the two latter fruits is probably due to the fact that unfulfilled threatenings of rain for many days postponed the irrigation until after the first fruit was harvested. In 1903, when irrigated before ripening, they increased in yield, respectively, 9.5 per cent. and 7 per cent. A comparison of three years—1903, when irrigated, and after having been irrigated the previous year; 1904, when not irrigated, and 1905—may be of interest:

	1903		1904		1905	
	Amount of water received.	Percentage increase in yield.	Amount of water received.	Percentage increase in yield.	Amount of water received.	Percentage increase in yield.
Asparagus	2 in.	— 8.0	0 in.	— 8.0	4.5 in.	— 8.0
Blackberries	3 in.	+ 4.5	0 in.	— 1.9	4.8 in.	+ 32.0
Raspberries	3 in.	+ 2.5	0 in.	+ 13.0	4.0 in.	+ 14.0
Currants	3 in.	+ 7.0	0 in.	+ 11.0	2.0 in.	+ 1.7
Gooseberries	3 in.	+ 9.0	0 in.	— 0.2	2.0 in.	+ 0.9

Asparagus was not irrigated this year during the cutting season. However, the fact that it was irrigated in 1903, and had been irrigated in 1902, and was still below the unirrigated plots, shows that in this experiment it has not lent itself kindly to irrigation. Next year's results will show whether irrigation, after cutting, fortifies roots for stronger growth in spring.

By plots the response to irrigation differs with different fertilizers, but with none so uniformly that it can be said this is the fertilizer to use if one is going to irrigate.

Increase in weight of total product due to irrigation occurs most frequently on the fifth and eighth plots, and the per cent. of increase upon these plots is greatest. The greatest increase in the size of fruit also occurs on these plots. This has been studied in detail in the case of blackberries. One hundred average berries from each plot were weighed and the number of berries in a quart (twenty-four ounces) counted, so as to check the accuracy of the first comparison. From these figures the following table was prepared:

TABLE No. 5.

Per Cent. Increase in Size of Berries on Different Plots Under Irrigation.

PLOTS IRRIGATED.	Early Harvest.	Wilson, Jr.	Erie.	Agawam.	Taylor.	Eldorado.
		%	%	%	%	%
5	....	....	+ 64	113	75	41
6	....	+ 25	+ 35	20	10	.7
7	....	— 4	— 8	38	7	3
8	....	+ 1.00	+ 1.62	100	100	16

Early Harvest and Wilson, Jr., plot 1, did not produce enough berries, after irrigation had begun, to allow of this comparison. From observation, however, there was no increase in Early Harvest berries on plots 6 and 7, whereas on plots 5 and 8 there was a large increase.

Percentage of increase in weight of total product due to irrigation:

Plot V. . . . . 72 per cent.
" VI. . . . . 10 "
" VII. . . . . 21 "
" VIII. . . . . 54 "

The general increase in size was 6 per cent. It is interesting to note that after one irrigation of one and one-half inches, 100 berries weighed eight ounces, and after a shower of .52 inch, 100 berries of *the same variety and plot weighed nine ounces.*

The varieties of all the fruits and of asparagus differ also in the way in which they respond to irrigation on different plots. This may be seen from the tables.

TABLE No. 6.

Asparagus.

VARIETIES.	UNIRRIGATED.											
	PLOT I.			PLOT II.			PLOT III.			PLOT IV.		
	First three cuttings.	Total yield.	Tops.	First three cuttings.	Total yield.	Tops.	First three cuttings.	Total yield.	Tops.	First three cuttings.	Total yield.	Tops.
	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.
Barr's Mammoth...	37.0	394.6	29.0	32.7	370.7	26.8	13.9	265.7	28.4	31.0	382.1	27.6
Donald's Elmira....	34.2	482.2	36.4	9.0	352.0	25.0	28.5	459.5	34.5	6.5	254.5	20.0
Columbian Mammoth White........	28.0	475.5	37.0	20.5	379.0	27.5	7.5	274.0	28.0	15.0	287.0	23.0
Palmetto...............	45.0	726.9	52.5	38.0	588.5	49.0	29.0	510.0	45.0	39.7	507.5	46.0
Conover's Colossal,	32.1	423.7	35.3	19.0	289.0	27.0	20.3	308.2	23.4	7.5	243.7	20.3
Giant Brunswick...	38.2	456.2	37.5	16.0	361.5	27.0	16.7	298.7	21.6	24.9	369.4	32.6
Total	214.5	2959.1	227.7	180.2	2340.7	182.3	115.9	2106.1	170.9	124.6	2044.2	169.5
Average, 8 crops..	178.1	1986.4	170.5	142.4	1646.0	127.2	104.9	1393.3	114.1	99.2	1090.2	109.3

VARIETIES.	IRRIGATED.											
	PLOT V.			PLOT VI.			PLOT VII.			PLOT VIII.		
	First three cuttings	Total yield.	Tops.	First three cuttings.	Total yield.	Tops.	First three cuttings.	Total yield.	Tops.	First three cuttings.	Total yield.	Tops.
	oz.	oz	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.
Barr's Mammoth...	32.0	352.0	30.0	15.2	245.1	14.3	24.8	311.9	27.4	5.0	234.5	20.5
Donald's Elmira....	36.0	333.5	35.0	17.7	325.8	31.0	10.4	238.1	19.6	8.5	312.9	33.2
Columbian Mammoth White........	31.0	453.7	37.5	35.9	389.0	26.2	12.5	275.0	21.5	24.5	291.0	32.0
Palmetto	17.5	388.0	40.5	30.0	611.5	43.5	42.7	540.5	49.0	33.7	571.0	50.3
Conover's Colossal,	37.0	330.5	34.5	50.6	465.0	39.2	27.5	275.5	31.5	21.3	315.0	28.3
Giant Brunswick...	18.2	346.6	21.0	18.8	344.2	30.0	25.7	461.2	43.4	21.8	244.0	24.2
Total	171.7	2254.3	198.5	168.2	2380.6	184.2	142.9	2102.2	192.4	114.8	1968.4	189.0
Average, 8 crops..	118.6	1665.3	158.1	138.8	1556.5	131.2	115.4	1458.9	125.1	92.7	1365.8	131.7

ASPARAGUS.

In comparison of fertilizers, the duplicate plots rank, as before stated: 1 + 5, first; 2 + 6, second; 3 + 7, third; 4 + 8, fourth. This is in accordance with the average yield for the last eight years, except that formerly plot 4 + 8 exceeded plot 3 + 7 by thirty ounces, while this year the difference is 200 ounces in favor of plot 3 + 7. The same relations hold for early yield, in this case entirely in accordance with the eight years' average.

In reference to irrigation, we recall a decrease in yield of eight per cent. on irrigated plots. In detail, the plots rank thus: 1, 6, 2, 5, 3, 7, 4, 8. It is therefore plain that manure and complete fertilizer excel with and without irrigation. The plot receiving complete fertilizer is the only one to exceed its duplicate when irrigated. The plots in early yield stand thus: 1, 5, 6, 7, 2, 4, 3, 8. But the fact that three irrigated plots stand before plot 2, with complete fertilizer, can mean little, since it is two years since the asparagus has been irrigated to affect early yield at all. On the whole, the irrigated plots exceed the unirrigated by 1 per cent., which is not as in the average for the previous years.

Among the varieties, only one (Conover's Colossal) was benefited by irrigation, and this to the extent of 14 per cent. The others increased on various plots, but not enough to make the whole above the unirrigated section. It is notable that not a single variety produced more on the manure plot under irrigation, while on the other plots there were various increases.

This is also true of the weight of the tops. There is an increase on all of the other plots, however, counter-balancing this so far as to make the total weights read 764 pounds to 750 pounds in favor of irrigation.

The following are the yields of the different varieties from the unirrigated plots alone, so that they may be compared with the four varieties set later and not irrigated. In order of productiveness, they are:

	Total Yield in Ounces.	Early Yield in Ounces.
Palmetto	2,352.9	141.0
Palmetto sel	1,777.3	83.0
Donald's Elmira	1,548.2	78.2
Donald's Elmira sel	1,506.5	107.7
Giant Brunswick	1,480.8	95.8
Columbian Mammoth White	1,415.5	71.0
Barr's Mammoth	1,413.1	113.7
Giant Argenteuil (five-year-old plants),	1,360.4	95.4
Moore's Cross-Bred	1,272.1	85.4
Conover's Colossal	1,259.6	78.3

Palmetto easily leads as the most productive, as well as the earliest. It is also almost rust-proof. Its quality and thickness of stalk surpasses all the other varieties except Giant Argenteuil. This latter variety cannot be compared with the others here given, as it has only been cutting five seasons, against eight for the others. Last year it stood first in early and third in total yield. Of the other varieties the next in importance is Donald's Elmira. Rust developed upon the asparagus the last of September. From rough estimates it appeared to be more serious on the two center plots than upon the manure plot, and the plot receiving complete fertilizer, bone, potash and nitrate of soda. It also seemed worse on the unirrigated than on the irrigated plots. Of all the varieties, Palmetto and Giant Argenteuil are unquestionably the most nearly rust-proof.

The crowns selected, because of large size when set, have not in any case done as well as the ordinary nursery stock after the first few years.

The statistics for these two rows, and for the new varieties—Moore's Cross-Bred and Giant Argenteuil—follow:

TABLE No. 7.

Asparagus—New Varieties and Selected Crowns.

VARIETIES.	UNIRRIGATED.											
	PLOT I.			PLOT II.			PLOT III.			PLOT IV.		
	First three cuttings.	Total yield.	Tops.	First three cuttings.	Total yield.	Tops.	First three cuttings.	Total yield.	Tops.	First three cuttings.	Total yield.	Tops.
	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.
Elmira, selected.....	48.5	565.0	38.0	38.2	450.0	39.6	10.0	204.5	19.0	16.0	287.0	27.0
Palmetto, "	27.0	488.5	45.5	28.0	411.0	40.6	10.0	428.0	49.0	23.0	424.8	40.7
Moore's Crossbred..	25.2	382.6	30.0	27.0	381.5	28.0	10.7	264.0	29.0	26.5	294.0	26.0
Giant Argenteuil...	20.0	252.5	35.5	24.6	332.7	35.3	16.0	329.0	37.5	31.8	446.2	54.6
	120.7	168.8	149.0	107.8	1555.2	142.9	46.7	1225.5	134.5	97.3	1452.0	148.3

TABLE No. 8.

Raspberries—Fertilizer Plots.

VARIETIES.	UNIRRIGATED.							
	PLOT I.		PLOT II.		PLOT III		PLOT IV.	
	Early yield.	Total yield.	Early yield.	Total yield.	Early yield.	Total yield.	Early yield.	Total yield.
	oz	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Cuthbert, set 1895	51.5	290.0	35.0	311.5	67.0	272.0	11.5	59.5
" " 1904	25.5	115.0	9.0	66.5	6.5	32.0	10.5	56.5
" " "	22.5	88.5	7.0	107.0	5.5	66.5	3.5	31.5
Cumberland, set 1904	26.5	62.0	21.5	45.5	35.0	66.5	27.0	54.0
" " "	37.0	98.5	18.5	63.5	36.5	68.0	19.0	43.5
" " "	14.5	37.0	3.5	9.5	8.5	15.0	25.5	37.5
Total in ounces	151.0	686.0	94.5	603.0	158.5	520.0	97.0	282.5
Total in quarts	7.0	31.1	4.2	27.4	7.2	23.6	4.4	12.8

VARIETIES.	IRRIGATED.							
	PLOT V.		PLOT VI.		PLOT VII.		PLOT VIII.	
	Early yield.	Total yield.	Early yield.	Total yield.	Early yield.	Total yield.	Early yield.	Total yield.
	oz.	oz.	oz.	oz.	oz	oz	oz	oz.
Cuthbert, set 1896	123.5	499.5	64.0	209.5	48.5	222.5	50.0	219.0
" " 1904	7.0	53.5	22.0	110.0	5.5	38.5	6.0	56.5
" " "	11.5	49.5	16.0	74.0	21.0	69.5	5.0	68.0
Cumberland, set 1904	57.0	138.5	55.5	101.5	10.5	19.5	28.0	50.0
" " "	25.5	47.5	32.5	72.0	35.5	61.0	22.0	43.5
" " "	45.0	85.5	13.5	30.5	26.5	42.5	19.5	37.5
Total in ounces	269.5	874.0	203.5	597.5	147.5	503.5	130.5	469.5
Total in quarts	12.2	39.7	9.2	27.1	6.7	22.9	5.9	21.3

RASPBERRIES.

Since in 1904 the last five rows in each block were reset (see table), leaving the first row of the planting of 1896, these new rows, fruiting for the first time, are not comparable with the latter; neither are the totals comparable with the yields of previous years. Thus in total product of all rows this year the rank in yield is in the same order that plots are numbered 1 + 5, 2 + 6, 3 + 7, 4 + 8, whereas before plot 3 + 7 had exceeded or equalled plot 1 + 5. In 1903, the average of five crops put manure as the least productive: now it exceeds the previously favored fertilizer by 537 ounces. This difference is not wholly due to the new rows, because the old row of Cuthbert's ranks its plots 1 + 5, 2 + 6, 3 + 7, 4 + 8.

Considering this year's yield alone, we find that, separately, the plots bear out the same relation, standing thus: (5, 1), (2, 6), (3, 7), (8, 4). It will be noticed that while plots 2 and 3 stand before plot 4, they are not stimulated to increase by irrigation. This is significant when it is found that in early yield plot 2 stands behind its duplicate, plot 6, by 113 per cent.; plot 3, however, still is greater where unirrigated. The plots in early yield stand 5, 6, 3, 1, 7, 8, 4, 2.

Under irrigation the total yields were increased 14 per cent.; early yields were increased 50 per cent. The increase for different plots read, for total yield: Plot 5, increase 27 per cent.; plot 6, decrease 1.2 per cent.; plot 7, decrease .3 per cent.; and plot 8, increase 21 per cent. For early yields: Plot 5, increase 7 per cent.; plot 6, 13 per cent.; plot 7, decrease 7 per cent.; plot 8, increase 34 per cent.

The increase from irrigation is greater on the old plants than on those recently set. Thus, Cuthbert, set 1896, increases in early 73 per cent., in total 23 per cent.; Cuthbert, set 1904, early, .44 per cent., in total .1 per cent.; and Cumberland, set 1904, 31 per cent. and .22 per cent., respectively.

The yields of these three divisions—that is, the averages for one row in each case—are as follows:

	Early.	Total Yield.
Cuthbert, 1896	451.0 oz.	2083.5 oz.
Cuthbert, 1904	92.0 "	563.9 "
Cumberland, 1904	217.6 "	441.6 "

TABLE No. 9.

Blackberries—Fertilizer Plots.

VARIETIES.	UNIRRIGATED.							
	PLOT I.		PLOT II.		PLOT III.		PLOT IV.	
	Early yield.	Total yield.	Early yield.	Total yield.	Early yield.	Total yield.	Early yield.	Total yield.
	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Early Harvest	29.0	51.0	28.0	45.5	24.0	35.0	6.0	8.0
Wilson Junior	16.0	81.0	64.0	217.5	35.0	161.0	16.5	158.0
Erie	31.5	189.0	15.0	179.0	23.0	186.5	38.0	175.5
Agawam	33.0	225.0	31.0	224.5	10.0	120.0	16.0	154.0
Taylor	7.0	254.5	23.5	246.0	12.5	202.5	12.0	155.0
Eldorado	57.0	280.5	29.5	268.0	14.5	190.0	15.0	145.0
Totals in ounces	173.5	1,031.5	191.0	1,180.5	119.0	895.0	108.5	790.5
Totals in quarts	7.2	43.0	7.9	49.2	4.9	37.3	4.3	33.0

VARIETIES.	IRRIGATED.							
	PLOT V.		PLOT VI.		PLOT VII.		PLOT VIII.	
	Early yield.	Total yield.	Early yield.	Total yield.	Early yield.	Total yield.	Early yield.	Total yield.
	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Early Harvest	40.0	87.0	48.5	62.5	36.0	48.0	25.0	42.0
Wilson Junior	40.0	187.5	11.5	78.0	9.0	163.5	3.0	121.0
Erie	75.0	568.5	16.0	143.0	8.0	186.5	14.5	285.0
Agawam	62.0	358.0	22.0	273.0	16.0	228.5	16.0	309.5
Taylor	4.5	290.5	20.5	219.0	9.0	155.0	17.0	252.5
Eldorado	14.5	312.0	19.0	295.0	20.0	302.0	18.5	267.0
Totals in ounces	236.0	1,793.5	137.5	1,070.5	98.0	1,088.5	94.0	1,227.0
Totals in quarts	9.8	74.7	5.7	44.6	4.1	45.1	3.9	51.1

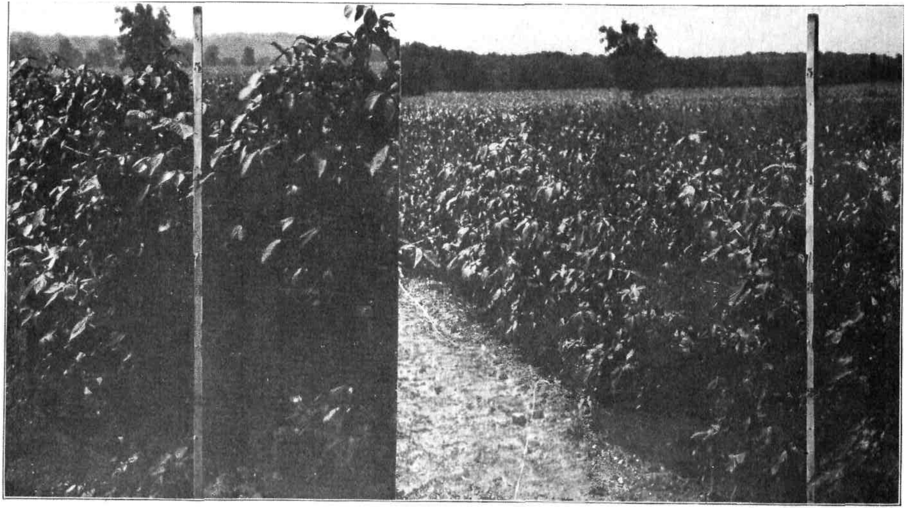
BLACKBERRIES.

In 1904 the blackberries were so badly winter-killed that the returns were not comparable with previous crops. This year, however, they have recovered in so far as to yield per plot quite in accordance with the average of yields up to 1904. Early Harvest was slightly injured this year, but so uniformly on all plots as not to affect the general relationship. Wilson, Jr., however, was injured on plot 1, which therefore ranks below the second plot of the four unirrigated, but in the average of duplicate plots it excels. Thus manure leads, with complete fertilizer second, as in the average of the six years' crops. Plot 4 + 8, however, stands before plot 3 + 7. This is caused by the increase which occurred in this plot from irrigation.

We have seen that irrigation has caused an increase of 32 per cent., on the whole; of 73 per cent. upon the manure plot, and of 54 per cent. upon the plot receiving complete fertilizer, bone, potash and nitrate of soda. Without additional nitrate of soda the increase is 21 per cent., while complete fertilizer alone falls behind the same unirrigated by 10 per cent. The plots therefore rank, including the unirrigated: 5, 8, 7, 2, 6, 1, 3, 4. It is significant that of the two best plots, manure and complete fertilizer, manure exceeds its duplicate when irrigated, complete fertilizer when not irrigated. While the poorest plot in point of the general return from fertilizer received, namely, plot 4, exceeds, when irrigated, both of the plots receiving complete fertilizer, and the manure plot, unirrigated.

In early yield this plot 8 stands last, even below its duplicate, unirrigated. This may be explained by the fact that the nitrate of soda was applied as late as June 22d, while the first fruit was picked July 6th. The plots in early yield rank 5, 2, 1, 6, 3, 4, 7, 8, the manure and complete fertilizer plots leading. Although plot 5 exceeds its duplicate by 36 per cent., it is the only plot which does, the irrigated block, on the whole, falling behind the other in early yield by 3.7 per cent.

Of the different varieties, all respond to irrigation except Wilson, Jr. The increase in size of each is given under the general discussion of irrigation. Their increases in total product are:



Irrigated. AGAWAM BLACKBERRIES. Unirrigated.

Early Harvest	64	per cent.
Wilson, Jr. (minus)	2	"
Erie	51	"
Agawam	61	"
Taylor	18	"
Eldorado	33	"

With increase in size of berries and in total product, there was also a marked increase in flavor and quality of the berry. The greater vigor of the bushes is seen in Fig. 1. These facts are true of all varieties, although they did not all respond to irrigation equally quickly or equally well. Erie retained good size and quality after the other berries had become small and almost worthless. The yields of the different varieties are as follows:

	Early Yield. Quarts.	Total Yield. Quarts.
Eldorado	7.8	85.8
Agawam	8.5	78.8
Erie	9.2	77.2
Taylor	4.4	74.0
Wilson, Jr.	6.6	42.1
Early Harvest	9.8	15.3

CURRANTS.

With currants and gooseberries, the series of fertilizers are: Manure, plots 1 and 4; bone, potash and acid phosphate, plots 2 and 5; and bone, potash and acid phosphate and nitrate of soda, plots 3 and 6. See Table No. 3.

Both currants and gooseberries were attacked by currant worm, but one spraying with Bordeaux mixture, containing Paris green, killed the worms.

On both irrigated and unirrigated plots the fertilizers rank, in importance, 1 + 4, 3 + 6, 2 + 5, as has been the case every year. Manure is highest in yield in every variety. Plots 3 + 6 rank second in all except White Grape. The irrigated plots show an increase of 1.7 per cent.; by plots it is 4 per cent. on plot 4 and .5 per cent. on plot 6, and a decrease of .5 per cent. on plot 5. The fact that under irrigation the yields increased in 1903 and in 1904, the subsequent year, without irrigation; and that this year, without irrigation, there was such a large drop, seems to point to the fact that the effects of

irrigation may be seen in the second year's crop only under good conditions. Perhaps they are less able to cope with adverse circumstances. Thus, this year, after maturing their crop in partially dry weather, the leaves dropped almost immediately, even though irrigated plentifully later.

Of the four varieties, Red Dutch held its leaves the longest. It, in fact, has the strongest bushes and produces the largest crop in total weight, though the berry is not as large as Fay's Prolific. The White Grape has not been found a popular market variety, though of good size and color. The varieties stand thus in productiveness:

Red Dutch	288.6	qts.
Victoria	261.7	"
White Grape	167.3	"
Fay's Prolific	135.7	"

TABLE No. 10.

Currants—Fertilizer Plots.

VARIETIES.	UNIRRIGATED.			IRRIGATED.		
	Plot I.	Plot II.	Plot III.	Plot IV.	Plot V.	Plot VI.
	oz.	oz.	oz.	oz.	oz.	oz.
Fay's Prolific	623.0	429.0	350.5	525.5	324.0	478.0
Red Dutch	1,199.0	643.0	928.5	1,143.0	851.0	1,008.0
Victoria	1,050.0	884.5	880.0	986.5	622.0	912.0
White Grape	672.0	526.0	639.5	457.5	506.0	546.0
Totals in ounces	2,944.0	2,422.0	2,798.5	3,062.5	2,308.0	2,939.0
Totals in quarts	147.2	121.1	139.4	153.1	115.1	146.9

GOOSEBERRIES.

According to the yields of previous crops, gooseberries should rank the fertilizers as currants do—that is, plots 1 + 4, 3 + 6, 2 + 5—but this year irrigation increased the yield on plot 5 so much as to make it rank second in the average of duplicates. Then the plots stand: 1, 4, 5, 3, 2, 6. The two manure plots first, and then the plot receiving bone, potash and acid phosphates, irrigated. This is the only plot which exceeds its duplicate unirrigated. The total increase from irrigation, then, is only .9 per cent. It must be remembered that irrigation this year did not occur until after the fruit was picked. Any increase would therefore be due to previous irrigation in 1903, when the increase was 9 per cent.

The varieties yielded as follows:

Houghton	305.5 qts.
Downing	297.6 "
Columbus	163.4 "
Triumph	136.4 "

Houghton, though giving the largest yields, is not the most desirable. Its berries are very small and its bushes unusually large. Columbus and Triumph produce the largest berries on bushes about one-half the size. Columbus, though smaller, is very sweet, and is not so likely to sun-scald.

TABLE No. 10.

Gooseberries.

VARIETIES.	UNIRRIGATED.			IRRIGATED.		
	Plot I.	Plot II.	Plot III.	Plot IV.	Plot V.	Plot VI.
	oz.	oz.	oz.	oz	oz.	oz.
Downing	1,525.0	942.0	1,065.5	1,341.0	1,062.5	1,099.0
Columbus	937.5	504.0	460.0	937.0	497.0	505.5
Houghton	1,373.0	910.0	1,122.0	1,564.0	1,373.0	999.5
Triumph	799.5	565.5	335.5	720.0	364.5	422.9
Totals in ounces	4,675.0	2,921.5	2,983.0	4,562.0	3,297.0	2,936.0
Totals in quarts	198.9	124.3	126.9	194.1	140.3	129.2

TREE FRUITS.

A comparison of fertilizers is not very conclusive, when dealing with the orchards, because there are only two trees of each variety in each plot. One of these may naturally produce more and larger fruit than the other; one may be diseased and one may not; one may even have been taken out. This latter fact, having often been the case, makes comparisons of entire plots difficult, even if individual irregularities might be equalized among greater numbers.

This year the dwarf pears were irrigated once, receiving 1.9 inches, but so late as to have effect only upon the size of this year's fruit; nor is there likely to be any future result, because a heavy rain of 2.58 inches came a few days afterward. Because of irregularities in the number of trees in each plot, no definite conclusions can be drawn. The Keiffers, however, run through all of the plots; adding these together, we find that the average weight of each No. I. fruit upon the irrigated plots is 7.7 ounces, and upon the unirrigated 8.0 ounces. The percentage of firsts upon the irrigated plots is 29 per cent. and upon the others 23 per cent. The differences on other varieties are even less marked.

PLUMS.

This year Newman and Shropshire Damson trees produced a heavy crop. The other varieties either did not set fruit or were hindered in ripening it by rot, curculio and dry weather. The extremely dry weather injured the trees very much. The dry winds burned the edges of the leaves badly, especially of the Lombard and Grand Duke varieties, and caused many to drop. For curculio, the trees were jarred during June, but many of the Grand Duke and Damson plums were stung; Newman trees blossomed very late, and were very little troubled by the insect.

The varieties were affected by rot as follows: Lombard produced seventy-nine pounds seven ounces good fruit to forty pounds fourteen ounces rotten. This variety did not rot until nearly ripe; it could therefore be weighed. Grand Duke and the Damsons, however, began almost as soon as the fruit set. Of the former, it is estimated that about nine-tenths of the crop was worthless this year, while of the latter, the proportion of culls was very small indeed. The Gages set only a few fruits, and these rotted. Of Victoria, about 60 per cent. were worthless—not weighed. The Newman trees show a difference between each other—several trees ripen their fruit from the last of July to the middle of August; these were entirely free from rot; other trees ripening later, during the wet weather which often occurs here during the last of August and early September, show a tendency to rot unless picked quite green.

TABLE No. 11.

Plums.

VARIETIES.	Date marketable.	IRRIGATED. PLOT I. Tree 1.	IRRIGATED. PLOT I. Tree 2.	IRRIGATED. PLOT II. Tree 1.	IRRIGATED. PLOT II. Tree 2.	UNIRRIGATED. PLOT III. Tree 1.	UNIRRIGATED. PLOT III. Tree 2.	UNIRRIGATED. PLOT IV. Tree 1.	UNIRRIGATED. PLOT IV. Tree 2.
		lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
Lombard	Aug. 28.	2— 8	....	....	....	....	29—11	....	88— 2
Newman............	July 28. Sept. 20.	75—14	77— 5	205—10	185—14	175— 0	278— 6	178— 0	117— 5
Shropshire Damson	Sept. 1-6.	64—15	51— 0	82— 9	81—15	55— 9	112— 8	87— 5	93—13
Grand Duke........	Aug. 28.	1— 9	0—12	....	4— 2	1— 6	8— 8	0—13	0—13
Total per row...	....	....	....	....	....	....	....	....	....
Total per plot...	....	....	....	....	....	....	....	....	....

VARIETY TREES.	Number of tree.	Date marketable.	Tree 1.	Tree 2.	Average yield per tree to date, with permanent varieties.	Number of years bearing.
			lbs. oz.	lbs. oz.	lbs. oz.	
Imperial Gage..	8	Aug. 28.	0— 8^{3}	6—14	8— 9	4
Victoria	6	Aug. 28.	85—12	14— 8	18— 8	4
Bavay's Green Gage	9	....	....	....	17— 8	5
Washington.....	12	....	....	....	0— 8^{2}	2
Burbank..........	8	....	....	....	41—13	6
Abundance.....	6	Aug. 4.	4— 9^{7}	2— 0	44—12	4
French Damson	9	Sept. 6.	62— 6	51—15	80—12	5
Satsuma Blood.	12	....	....	....	15—10	4
Lombard	....	....	....	....	25— 1	6
Newman..........	....	....	....	....	107—13	7
Shropshire Damson.........	....	....	....	....	47— 0	5
Grand Duke....	....	....	....	....	9— 0	5

CHERRIES.

The cherry crop this year was light, although the blossoms were not frosted and there were few losses from birds, and none from insects or blights.

TABLE No. 12.

Cherries.

VARIETIES.	Date marketable.	IRRIGATED. PLOT I. TOTAL YIELD. Tree 1.	IRRIGATED. PLOT I. TOTAL YIELD. Tree 2.	IRRIGATED. PLOT II. TOTAL YIELD. Tree 1.	IRRIGATED. PLOT II. TOTAL YIELD. Tree 2.	UNIRRIGATED. PLOT III. TOTAL YIELD. Tree 1.	UNIRRIGATED. PLOT III. TOTAL YIELD. Tree 2.	UNIRRIGATED. PLOT IV. TOTAL YIELD. Tree 1.	UNIRRIGATED. PLOT IV. TOTAL YIELD. Tree 2.
		lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
Large Montmorency	June 28.	2— 0	29— 8	8— 7	1—12	0— 8	1—10	6—10	1—14
Louis Phillippi	June 19.	4— 5	5— 4	9— 5	4— 8	8— 2	1—14[2]	7—15	7—15
Early Richmond,	June 15–17.	16—18	48— 7	32—10	58— 8	28— 6	58— 7	54— 2	58—14
Total per row,	....	23— 2	77—14	45— 6	64— 7	26—11	61—15[2]	68—11	68—11
Total per plot,	....	101— 0	....	109—18	....	88—10	....	137— 6	....

VARIETY TREES.	Number of tree.*	Date marketable.	1905. TOTAL YIELDS. Tree 1.	1905. TOTAL YIELDS. Tree 2.	Average yield per tree to date. Varieties in permanent plots for comparison.	Number of years bearing.
			lbs. oz.	lbs. oz.	lbs. oz.	
Osthein	8	June 28.	27— 9	13— 8	12— 7	7
Royal Duke	6	June 22.	18— 2	8— 7	8— 6	5
English Morello	9, 12	July 6-12.	89— 7	47—10	57—12	7
Montmorency Ordinaire	....	June 28.	68—12	62— 6	56—18	7
Reine Hortense	8, 6	June 19.	8— 9[a]	2—18	2—14	7
May Duke	8, 6	June 10-19.	42—11[a]	19— 2	24— 7	7
Large Montmorency	....	....	....	....	8—10	5
Louis Phillippi	....	....	....	....	6—18	6
Early Richmond	....	....	....	....	85— 9	7

*Trees numbered alike have similar treatment; two numbers refer to tree 1 and 2, respectively.

PEARS—DWARF, AND DWARF BY PRUNING.

All dwarf pears, except the Keiffers, were sprayed April 6th with lime, sulphur and caustic soda. The Bartletts, however, still show live scale—some appearing on the fruit. The late pears, especially the Le Conte, and a smaller proportion of the Keiffers, were affected by codlin moth. The Lawrence pears showed a disposition to drop before matured. This year one Lawrence was removed because blighted. Blight has been less severe on dwarf than on standard trees.

TABLE No. 13.

Dwarf Pears.

VARIETIES.	IRRIGATED.																	
	PLOT I.						PLOT II.						PLOT III.					
	TREE 1.			TREE 2.			TREE 1.			TREE 2.			TREE 1.			TREE 2.		
	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.
Dwarfs.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.
Lawrence	29	7— 4	4.0	35	7— 4	3.3	22	2—13	2.0	71	9—13	2.2	91	14— 8	2.5	81	19— 9	3.8
Bartlett	8	0—14	4.6	5	1— 3	3.8	27	8— 0	4.7	61	18—13	5.0	191	58— 7	4.9	166	46— 8	4.4
Dwarfs by Cutting.																		
Lawrence	14	3— 6	4.0	91	24—11	4.2	......	......	......	......	......	......	......	......	......	160	45—15	4.6
Bartlett	16	6— 0	6.0	157	48— 3	4.9	79	24—15	5.0	6	1—14	5.0	7	2— 4	5.1	30	9—15	5.3
Keiffer	431	119— 5	4.4	707	261—10	5.6	1264	428— 2	5.4	1141	380—15	5.3	866	342— 5	5.8	1045	345—12	5.2

TABLE No. 13—Continued.

Dwarf Pears.

VARIETIES.	UNIRRIGATED.																	
	PLOT IV.						PLOT V.						PLOT VI.					
	TREE 1.			TREE 2.			TREE 1.			TREE 2.			TREE 1.			TREE 2.		
	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.
Dwarfs.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz	oz.		lbs. oz.	oz.		lbs. oz.	oz.
Lawrence	128	32—15	4.1	......	......	......	196	37—10	3.0	52	21— 9	6.6	41	9— 7	3.7	164	55—10	5.4
Bartlett	......	......	......	......	......	......	159	35—12	3.6	87	21—12	4.0	......	......	......	......	......	......
Dwarfs by Cutting.																		
Lawrence	......	......	......	27	5— 6	3.2	......	......	......	112	33— 7	4.7	152	47— 1	5.0	295	74—13	4.0
Bartlett	60	14—10	3.9	1	0— 6	6.0	......	......	......	17	5— 6	5.0	131	38— 6	4.6	84	26— 9	5.0
Keiffer	1024	319—13	5.0	1804	339— 2	4.7	924	333— 1	5.7	1161	387— 8	5.3	796	292— 4	5.7	904	363— 1	6.4

TABLE No. 14.

Dwarf Pears—Varieties.

VARIETIES.	Number of tree.	Date marketable.	1905. Tree 1. Number of fruits.	Tree 1. Weight.	Tree 1. Average weight per fruit.	Tree 2. Number of fruits.	Tree 2. Weight.	Tree 2. Average weight per fruit.	Average yield per tree to date. Number of fruits.	Average yield per tree to date. Weight.	Average yield per tree to date. Average weight per fruit.	Number of years bearing.
Dwarfs.				lbs. oz.	lbs. oz.		lbs. oz.	oz.		lbs. oz.	oz.	6
Margaret	8	Aug. 7.	......	......	......	25	2— 6	1.5	25	3— 4	2.0	5
Clapp's Favorite	6	Aug. 12.	154	29—14	3— 1	228	38— 0	2.6	148	26— 7	3.4	5
Howell	9	Sept. 2.	93	26— 5	4— 5	106	38— 7	5.8	75	30— 3	6.4	6
Angouleme	12	Sept. 18.	215	58—12	4— 3	142	46—12	4.1	127	32— 1	4.0	6
White Doyenne	15	Sept. 12.	321	62— 7	3— 2	468	93— 0	3.1	291	59— 4	3.2	6
Seckel	18	Sept. 2-9.	84	8— 6	1— 6	75	6—14	1.6	55	6— 3	1.8	6
Lawrence	......	......	......	......	......	......	......	......	50	12— 6	3.9	6
Bartlett	......	......	......	......	......	......	......	......	68	17—11	4.1	6
Dwarfs by Cutting.												
Le Conte	6	Sept. 30.	687	230—15	5— 8	52	20— 1	6.1	258	94—13	6.9	6
Clapp's Favorite	12	Aug. 18.	113	36— 3	5— 1	19	6— 7	5.4	46	15— 2	5.2	3
Seckel	{ 15 3	} Sept. 2.	......	......	......	138	22—15	2.7	64	11— 3	2.8	2
Belle Lucretive	{ 6 9	}	......	......	......	165	27—12	2.6	80	15— 4	3.0	5
Margaret	{ 12 15	}	157	29— 8	3— 0	......	......	......	80	13—14	2.7	3
Howell	18	......	79	25— 2	5— 1	7	2— 0	4.5	30	9— 4	4.9	3
Anjou	3	......	161	55—11	5— 5	......	......	......	54	18—12	5.5	3
Clarigean	9	......	5	1—10	5— 2	48	23—13	8.0	21	10— 5	7.8	6
Sheldon	18	......	......	......	......	......	......	......	......	......	......	......
Lawrence	......	......	......	......	......	......	......	......	56	16— 0	4.5	5
Bartlett	......	......	......	......	......	......	......	......	39	12— 2	5.0	6
Keiffer	......	......	......	......	......	......	......	......	617	206—14	5.3	6

* Trees 3 and 12, 6 and 15, and 9 and 18 have similar treatment because plots are duplicated for irrigation.

PEARS—STANDARD.

The pear crop this year was very good. There were present, however, some San José scale and codlin moths. The worms appeared in the late fruit only. Although sprayed in spring, scale showed itself on the Bartletts, Koonces, Angels, Seckels; one of these latter trees was removed because dead of blight; also one Clapp's Favorite. The Flemish Beauty trees were also troubled with leaf blight. For this they were sprayed twice with Bordeaux mixture, at the same time the apples were sprayed; it, however, only partially checked the malady.

TABLE No. 15.

Standard Pears.

VARIETIES.	PLOT I.						PLOT II.						PLOT III.					
	TREE 1.			TREE 2.			TREE 1.			TREE 2.			TREE 1.			TREE 2.		
	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.
		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz	oz.
Lawrence	264	60—13	3.6	82	18— 2	3.0	358	64— 4	2.8	405	97—13	3.8	236	70— 4	4.7	486	133—10	4.4
Bartlett	7	2— 6	5.4	224	63— 1	4.5	118	41— 0	5.5	286	51—10	5.5	107	38— 1	5.6	336	108—10	5.1
Keiffer	1,169	205— 9	2.8	535	112— 6	3.3	1,692	534—11	5.0	874	304— 2	5.5	780	270— 0	5.9	1,322	376— 3	4.5
Clapp's Favorite				194	44— 8	3.6							265	81— 8	4.9	167	49—15	4.4
Sheldon	90	34— 3	6.0							101	33—15	5.8	71	24— 6	5.5	24	9— 2	6.0
Seckel	32	4—13	2.4	160	26— 8	2.6	1	0— 4	4.0	124	20— 2	2.6	284	42— 2	2.3			

TABLE No. 16—Continued.

Standard Pears.

VARIETIES.	Number of tree.*	PLOT I. TREE 1. Number of fruits.	Weight.	Average weight per fruit.	PLOT I. TREE 2. Number of fruits.	Weight.	Average weight per fruit.	AVERAGE YIELD PER TREE TO DATE. Number of fruits.	Weight.	Weight per fruit.	Number of years bearing.
			lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.	
Koonce	8	......	......	......	31	8—15*	2.1	10	1—15	8.1	4
Dorset	9	294	94—12	5.1	724	215— 9	4.7	318	81— 5	4.0	5
Angel	3	205	46—11	3.6	67	22— 4	5.3	86	22— 8	4.1	6
Flemish Beauty	6	129	58— 7	6.6	38	15—12	6.6	55	21—14	6.8	3
Giffard	6	174	21— 0	1.9	......	......	......	188	27— 1	2.3	2
Lady Clapp	9	70	22— 9	5.1	......	......	......	45	14—12	5.2	5
Lawrence	......	......	......	......	......	......	......	168	40—15	3.9	6
Bartlett	......	......	......	......	......	......	......	158	47—11	5.0	6
Keiffer	......	......	......	......	......	......	......	996	276— 5	4.4	6
Clapp's Favorite	......	......	......	......	......	......	......	125	35— 3	4.2	3
Sheldon	......	......	......	......	......	......	......	48	16— 8	5.5	2
Seckel	......	......	......	......	......	......	......	126	18—15	2.4	4

* Trees numbered alike have similar treatment.

APPLES.

Although many enemies were fighting the trees this year, they succeeded in producing good crops. The San José scale was present, and, although sprayed April 6th with lime, sulphur and caustic soda, still appeared to some extent on the fruit, the Baldwin trees being affected more than others. Later several adverse factors combined, namely, very dry weather, the fungus *Phyllosticta* sp., and dry hot winds, with consequent dropping of the leaves. The trees were sprayed twice with Bordeaux mixture and Paris green to destroy the codling moth, but the worms still appeared in the late apples.

TABLE No. 16.

Apples.

VARIETIES.	PLOT I.						PLOT II.						PLOT III.					
	TREE 1.			TREE 2.			TREE 1.			TREE 2.			TREE 1.			TREE 2.		
	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.
		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.
Smith's Cider	2,014	248- 8	1.9	1,681	263- 6	2.5	2,753	487- 9	2.8	2,086	285- 8	2.1	1,116	20-11	2.9	1,645	299- 1	2.9
Baldwin	....	....	......	655	222- 8	5.4	189	33-11	2.8	50	18-14	6.0	89	12- 9	5.1	109	29-15	4.4
King Tompkins	18	3-10	3.2	56	15-11	4.8	105	57- 0	8.6	66	28-11	6.9	150	66- 0	7.0	....	....	......
Jonathan	....	....	......	1,050	202- 3	3.0	1,250	241- 6	3.0	1,214	252-12	3.3	....	....	......	775	205- 5	4.2
Oldenburg	185	14- 8	1.5	182	14-10	1.7	364	41- 8	1.8	281	37- 2	2.1	186	18- 9	2.1	117	16- 0	2.1
Gravenstein	....	....	......	16	4-14	4.8	80	18-13	3.7	....	....	......	80	7-12	4.1	25	8-12	5.6

TABLE No. 16—Continued.

Apples.

VARIETIES.	Number of tree.	Date marketable.	PLOT I.					
			TREE 1.			TREE 2.		
			Number of fruits.	Weight.	Average weight per fruit.	Number of fruits.	Weight.	Average weight per fruit.
				lbs. oz.	oz.		lbs. oz	oz.
Stump of the World	3	Aug. 28.	5	0—14	2.8	8	0— 9²	3.5
Ben Davis	6	....	1,041	240—11	3.7	341	104— 9	4.9
Yellow Transparent	8	July 20.	329	47— 5	2.8	114	17—15	2.5
Monmouth Pippin	6	Oct. 6.	28	8—13	5.0	29	7— 8	4.0
Williams' Favorite	8	Aug. 7.	83	10—11	2.0	64	11— 1	2.7
Barry	6	....	604	112—15	3.0	410	79— 3	3.0

PEACHES.

The peach orchard shows very little plot relationship this year, because so many trees have been reset with odd varieties. This year, also, more trees were removed, several never having recovered from uprooting by a wind storm in 1902. The orchard was not sprayed this spring and therefore the scale is quite plentiful. *Phyllosticta* has also injured many of the trees.

TABLE No. 17.

Peaches.

VARIETIES.	Date marketable.	PLOT I. Tree 1. Number of fruits.	Weight.	Per cent. No. I. fruits.	Average weight per fruit.	Per cent. No. II. fruits.	Average weight per fruit.	Number of thinnings.	Tree 2. Number of fruits.	Weight.	Per cent. No. I. fruits.	Average weight per fruit.	Per cent. No. II. fruits.	Average weight per fruit.	Number of thinnings.
			lbs oz.		oz.		oz.			lbs. oz.		oz		oz.	
Susquehanna	Sept. 18-16.	148	25—8	14.1	5.1	13.5	3.5	....	18.	22—15	9.2	5.0	7.9	3.4	....
Stevens' Rareripe	Sept. 28-30.	690	62—9	11.0	1.5	56.5	1.2	....	465	80—6	2.3	1.8	48.1	1.0	....
Elberta	Sept. 18.	116	14—9	....	....	68.8	2.0	....	....	....	....	....	....	....	....
Crawford's Late	Sept. 18-19.	811	48—8	20.5	2.8	27.0	2.0	53	....	....	....	....	....	....	....
Reeve's Favorite	{Aug. 31. / Sept. 6.}	268	27—15	20.1	2.2	39.5	1.6	88	9	2—18	66.6	5.6	....	....	....
Old Mixon	Sept. 12-13.	582	68—8	10.8	3.4	25.0	1.9	157	685	71—10	1.8	3.6	29.9	2.1	445

TABLE No. 17—Continued.

Peaches.

VARIETIES.	PLOT II. Tree 1. Number of fruits.	Weight.	Per cent. No. I. fruits.	Average weight per fruit.	Per cent. No. II. fruits.	Average weight per fruit.	Number of thinnings.	Tree 2. Number of fruits.	Weight.	Per cent. No. I. fruits.	Average weight per fruit.	Per cent. No. II. fruits	Average weight per fruit.	Number of thinnings.
		lbs. oz.		oz.		oz			lbs. oz.		oz.		oz.	
Susquehanna	176	84—15	15.3	5.8	51.1	8.0	....	42	8— 4	....	....	7.1	2.0	....
Stevens' Rareripe	115	8— 1	1.7	2.0	55.6	1.2	....	1407	124—15	6.8	2.0	63.5	1.4	129
Elberta	140	12—14	12.8	1.8	42.7	1.4	....	235	28— 2	15.0	1.9	62.9	1.4	162
Crawford's Late	780	121—13	46.0	2.8	28.4	2.8	188	....	....	....	....	....	....	....
Reeve's Favorite	....	....	....	....	....	....	....	725	184— 8	28.0	8.7	40.9	2.8	81
Old Mixon	1388	187— 8	9.7	8.5	37.6	2.5	810	780	98—11	20.8	8.5	32.1	2.1	428

TABLE No. 17A.

Peaches.

VARIETIES.	Plot III. Tree 1. Number of fruits.	Weight.	Per cent. No. I. fruits.	Average weight per fruit.	Per cent. No. II. fruits.	Average weight per fruit.	Number of thinnings.	Tree 2. Number of fruits.	Weight.	Per cent. No. I. fruits.	Average weight per fruit.	Per cent. No. II. fruits.	Average weight per fruit.	Number of thinnings.
		lbs. oz		oz.		oz.			lbs. oz.		oz.		oz.	
Susquehanna	292	74—14	36.3	5.3	28.0	4.0	58	354	54—10	8.4	3.5	70.8	2.5	348
Steven's Rareripe	520	66—10	27.1	2.8	43.0	2.6	194	909	115— 6	26.0	2.5	58.6	1.9	412
Elberta	511	105— 4	38.5	3.7	45.9	2.9	162	26	6— 1	34.6	4.4	15.8	3.2	....
Crawford's Late	470	70— 8	6.8	3.6	56.2	2.5	180	....	....	....	....	....	....	....
Reeve's Favorite	409	64— 8	17.3	3.5	47.4	2.8	55	272	63— 2	32.3	3.8	27.2	2.9	....
Old Mixon	654	48—10	....	....	32.4	1.3	148	698	52—15	11.3	2.2	34.2	0.9	70

TABLE No. 17A—Continued.

Peaches.

VARIETIES.	PLOT IV. Tree 1. Number of fruits.	Weight.	Per cent. No. I. fruits.	Average weight per fruit.	Per cent. No. II. fruits.	Average weight per fruit.	Number of thinnings.	Tree 2. Number of fruits.	Weight.	Per cent. No. I. fruits	Average weight per fruit.	Per cent. No. II. fruits.	Average weight per fruit.	Number of thinnings.
		lbs. oz.		oz.		oz.			lbs. oz.		oz.		oz.	
Susquehanna	169	51— 0	28.2	6.3	37.2	4.4	15	38	8— 8	21.2	4.4	78.7	4.0	....
Steven's Bareripe	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Elberta	894	158— 0	34.6	3.1	56.8	2.6	291	252	52— 7	28.5	3.6	84.1	2.6	100
Crawford's Late	585	106— 4	50.4	3.2	28.7	2.4	287	400	84— 0	58.0	3.7	18.0	3.0	82
Reeve's Favorite	357	69— 2	29.4	3.7	40.3	3.0	69	439	73—10	16.3	4.0	46.0	2.6	87
Old Mixon	....	....	....	....	....	....	....	....	....	....	....	....	....	....

Peaches—Varieties.

Number of tree.*	VARIETIES.	Date marketable.	Date planted.	Number of years bearing.	TREE 1. Number of fruits.	TREE 1. Weight.	TREE 1. Average weight per fruit.	TREE 1. Per cent. No. I. fruits.	TREE 1. Average weight.	TREE 2. Number of fruits.	TREE 2. Weight.	TREE 2. Average weight per fruit.	TREE 2. Per cent. No. I. fruits.	TREE 2. Average weight per fruit.
						lbs. oz.			oz.		lbs. oz.	oz.		oz.
8	Triumph	Aug. 12.	1896	5	98	4— 8	0.7	....	....	184	10—15	0.9	....	.....
6	Ward's Late	Sept. 25. Oct. 5.	1896	7	565	42— 6	1.2	1.9	2.0	288	82— 7	2.1	8.7	2.1
9	Surpasse	Aug. 31. Sept. 6.	1896	6	1235	179—10	2.4	80.0	8.0	....	....	....	....	.....
8	Alexander	July 28. Sept. 3.	1902	1	82	4— 1	2.0	58.1	2.2	25	3— 6	2.1	56.0	2.4
6	Champion	Aug. 26. Sept. 6.	1896	7	1268	196— 4	2.4	18.0	8.5	1087	200— 7	2.9	29.5	4.2
9	Klondyke	Sept. 27.	1900	1	25	4— 0	2.5	....	....	81	4— 8	0.9	4.9	2.0
*	Crosby	Sept. 18.	1896	6	1281	164— 3	2.0	1.4	8.0	1274	163— 2	2.0	5.8	2.9
9	Sneed	July 7.	1896	6	681	42— 6	0.9	21.4	1.3	....	....	....	....	.....
6	Foster	Aug. 30.	1902	1	2	0— 8[a]	4.0	....	....	1	0— 4[a]	2.2	....	4.5
8	Carmen	Aug. 11.	1901	1	51	10— 4	3.2	84.3	3.2	....	....	....	....	.....
*	Chair's Choice	Sept. 13.	1902	1	2	0—11	5.5	....	....	....	....	....	....	.....
8	Greensboro	....	1901	.....	....	....	....	....	....	....	....	....	....	.....

Champion—Ward's Late, only varieties that fruited last year. *Crosby—Two trees in Plot 4. Chair's Choice—Plot 1. Other trees numbered alike eceive similar treatment.

REPORT OF THE DAIRY HUSBANDMAN.

REPORT OF THE DAIRY HUSBANDMAN.

I. Feeding Experiments.

Three experiments were conducted between December, 1904, and May, 1905. One with dried beet pulp as a substitute for silage, and one with alfalfa hay as a substitute for purchased feeds, have been published in separate bulletins, and only the summaries are included in this report. An experiment with Climax distillers' grains compared with dried brewers' grains and cottonseed meal, show the distillers' grains to be economical and productive of good results.

II. Forage Crops, 1905.

The usual system of supplying crops as the roughage to the dairy herd from May 1st to the middle of October has been continued, and soiling crop rotations are tabulated with food nutrients for comparison with clover hay, wheat bran and corn meal. Notes on forage crops are given and experiments with inoculation of alfalfa on acre plots and cylinder experiments showing the effect of different applications of lime on the yield of alfalfa are given in detail.

Variety experiments with cow peas and soy beans indicate that several varieties of cow peas will mature seed in this region in a favorable season, and that the soy beans will mature in a much shorter season. Variety tests of corn for the silo have been continued, with results showing the Southern White and White Flint still in the lead. Comparisons of cost of raising soiling crops and silage corn is made. Top-dressings of nitrate of soda give a decided gain in yield of rye fodder, but comparatively small increase with wheat and winter vetch.

III. Experiments with the Dairy Herd.

This includes an experiment of family breeding to show the effect of breeding a pure-bred Guernsey sire on high-grade common stock, with especial reference to the fat content and color of the milk. Economic ways of making sanitary cattle mangers and milk-rooms are illustrated, and the necessity of keeping milk records and making fat tests are shown by eight years' records of the College Farm herd.

REPORT OF THE DAIRY HUSBANDMAN.

I. FEEDING EXPERIMENTS.

Since the last report was issued Bulletin No. 190, on "Alfalfa," has been published, treating the subject under the following headings:

I. Alfalfa as a Forage Crop.
II. Methods of Culture.
III. Alfalfa in New Jersey.
IV. Alfalfa Hay Versus Purchased Feeds.

The bulletin includes the following summary:

Summary.

I. Alfalfa: Importance as a Forage Crop—
- *a.* It enriches the soil in nitrogen from bacteria-inhabiting tubercles on the roots.
- *b.* In comparing food nutrients with that of other forage plants and mill feeds, alfalfa contains more protein than any other fodder, and therefore can be used in a ration to replace mill feeds.
- *c.* Large yields of green forage or hay can be secured, 16 to 26 tons of the former and 3 to 6.5 of the latter, per acre.
- *d.* Permanency—A well established field producing good crops for several years.

II. Methods of Culture—
- *a.* A well prepared seed-bed insures a good start to the young alfalfa plants.
- *b.* A liberal application of lime neutralizes acids in the soil, assists the assimilation of plant-food, and helps the retention of moisture.
- *c.* Alfalfa responds to an application of mineral fertilizer, phosphoric acid and potash, and requires but little applied nitrogen.
- *d.* New fields probably need inoculation of bacteria by application of soil from a well established field, or by treating the seed with prepared cultures.
- *e.* August seeding reduces the danger of weeds choking the young alfalfa plants. The young growth acting as a protection to the roots in winter.

III. Experience of Farmers in Growing Alfalfa—
- *a.* Alfalfa can be successfully grown.
- *b.* Well established fields are now located in fifteen counties.

IV. Alfalfa Hay versus Purchased Feeds—

a. A ration consisting of purchased feeds (bran, dried brewers' grains and cottonseed meal), corn silage and cornstalks, produced, respectively, 3.7 per cent. and 7.2 per cent. more milk and butter than a ration almost entirely of alfalfa hay and corn silage; 100 pounds of digestible nutrients of the alfalfa ration produced 176 pounds of milk to 161 pounds from the same amount of nutrients from the feed ration.

b. The purchased feed ration produced milk with an average of 0.15 per cent. more butter-fat.

c. A home-grown ration of alfalfa hay and corn silage, fed to four cows sixty days, in comparison with a purchased feed ration, with the same number of cows, the same length of time, cost, respectively, $30.03 and $47.05, or 12.5 and 19.6 cents per cow per day, with the alfalfa ration.

There is a net gain of 24.3 cents per 100 pounds and one-half of a cent per quart of milk, or a saving of 33.7 per cent. and 31.5 per cent., respectively, for milk and butter, with the home-grown ration.

The cost of feed to produce one pound of butter was, respectively, 10.17 and 14.86 cents, or 4.69 cents in favor of the alfalfa ration.

When purchased feeds average $25 per ton, alfalfa hay is worth $16.50, to feed with corn silage.

The animals maintained a good, healthy condition on both rations.

Comparison of Experiments.

The result of this experiment agrees quite closely with results from similar experiments conducted by this Station:

a. Three experiments with alfalfa hay versus purchased feeds gave an average net gain of 28.3 per cent. and 27.0 per cent., respectively, in milk and butter, from the alfalfa ration.

b. Cow pea hay was equal in feeding value to alfalfa hay, while crimson clover hay seemed less valuable.

c. Cow pea or soy bean silage, with alfalfa or crimson clover hay, returned less net gain in milk and butter.

Bulletin 189, also issued since the last report, contains the results of an experiment with "Dried Beet Pulp as a Substitute for Corn Silage." The summary of which is as follows:

Summary.

1. The total yields of milk and butter are 2,016.6 pounds and 97.26 pounds, respectively, from the beet pulp, and 1,811.0 pounds of milk

and 87.82 pounds of butter from the silage ration. A net gain of 205.6 pounds of milk, or 10.2 per cent., and 9.44 pounds of butter, or 9.7 per cent., for the beet pulp ration.

2. The beet pulp ration cost $2.25 more for the experiment, or 3.7 cents daily per cow, than the silage ration. This makes the cost of milk per 100 pounds and per quart 2.8 and 0.06 cents, respectively, in favor of the silage ration.

The cost of production of butter was, also, 0.61 cents less per pound from the silage ration. The net gain in favor of this ration was therefore 3.31 per cent. and 3.48 per cent., respectively, for milk and butter.

From the beet pulp ration, each 100 pounds of digestible nutrients consumed produced 11.0 pounds more milk and 0.9 pounds more butter than from the silage ration.

3. While the fat tests varied slightly with individual animals, the quality of the milk from the two rations remained practically the same, the average percentage of fat for each ration being 4.13 per cent. and 4.14 per cent., respectively.

4. From the first the cows lost flesh on the beet pulp, yet gained on the silage ration, the average gain per cow for the experiment being 245 pounds from the silage ration.

CLIMAX DISTILLERY GRAINS VERSUS DRIED BREWERS' GRAINS AND COTTONSEED MEAL.

Climax Grains is a trade name given to one brand of dried distillery residue from the manufacture of alcohol, spirits or whiskey. Briefly stated, the process consists of grinding together several cereals, such as corn, rye, oats and barley, and heating them with a solution of malt to convert the starch into sugar. The proportion and kind of grain used depends upon the kind of liquor desired. The addition of yeast converts the sugar into alcohol, and the mixture is then distilled. The residue or slops remaining is then filtered, dried and put upon the market as cattle feed.

They are somewhat sour to the taste, consisting chiefly of hull, germ and gluten, with some less soluble carbohydrates, and their quality depends upon the kind of mash used, and also somewhat on the drying. Ajax Feed, Ajax Flakes, Atlas Gluten Meal, Atlas Meal, Climax Grains, Biles' "X," "XX," "XXX," "XXXX" Grains are names different manufacturers have given for their particular product.

Distillery grains may be divided into three classes: (A) Alcohol

or spirit grains, which are of the highest quality and uniform grade, where corn is chiefly the one grain used. They show an average of 35 per cent. of protein and over 11 per cent. of fat. (B) Bourbon whiskey grains, containing more smaller grains, such as rye, oats and barley, and varying from 23 per cent. to 38 per cent. of protein, and 6 per cent. to 15 per cent. of fat. (C) Rye whiskey grains, which are the poorest in quality, containing 17 per cent. to 24 per cent. protein, and 5 per cent. to 7 per cent. of fat.

Of the several brands now put upon the market in this State, Climax Grains represent an average high-grade distillery product, and therefore selected for this experiment. The analysis made by this Station shows it to contain:

Water	5.08	per cent.
Ash	2.52	"
Protein	34.59	"
Fat	11.54	"
Fiber	10.60	"
Nitrogen-free Extracts	35.67	"

Digestion tests of distillery grains made by Dr. J. B. Lindsay* show a relatively high digestibility, excepting the very cheapest grade, quite similar to gluten feed, showing digestible 77 per cent. of dry matter, 71 per cent. of protein, 96 per cent. of fat and 79 per cent. of extract matter.

Plan of Experiment.

Dried brewers' grains have heretofore been an economical source of protein, and a ration with bran, dried brewers' grains and cottonseed meal for the feed portion, and corn silage as roughage, has been very popular, as well as productive of good results. The demand for brewery grains has caused an advance in price, and it has become a question whether it is profitable to feed them. It was the object of this experiment, therefore, to test one of the dried distillery grains and to compare it in a ration with dried brewers' grains and cottonseed meal. Bran was common to both rations.

The experiment was divided into two periods of fifteen days each, with five days' preliminary feeding previous to Period I. and five

* Hatch Exp. Station of Massachusetts, 13th Annual Report, p. 48.

days' intermediate feeding between periods. Four cows were divided into lots of two each—Lot I. receiving the distillery grain ration, Lot II. dried brewers' grains, and cottonseed ration in Period I., while the order was reversed in Period II. to counterbalance the natural shrinkage of milk.

Animals and Management.

The four cows selected represent average dairy types of animals. Cherry was a pure-bred Ayrshire, Zola a grade Holstein, Buttercup a grade Guernsey and Lilith a grade Jersey. Cherry and Zola hold good yearly records for milk and butter, Lilith valued especially for her record in production of butter, while Buttercup was the least valuable of the four cows, both in production of milk and butter.

They occupied stalls in the same row under similar conditions of light and ventilation, and the management, in respect to feeding, exercising, watering, milking and weighing and sampling of milk, were similar. Each cow was milked by the same person throughout the experiments, the milk was weighed on a spring balance and composite samples were taken from aliquot parts of each milking. The method employed was to thoroughly mix the freshly-drawn milk by pouring back and forth, and by means of a graduated pipette take one cubic centimeter for each pound of milk produced, preserving with potassium bichromate in a well-stoppered bottle. The composite samples were tested in a steam turbine Babcock machine.

Rations Used and Nutrients Consumed.

The roughage part of each ration consisted of forty pounds of corn silage, fresh and sweet, with a good proportion of ears, well matured, and the analysis showed it to be above the average in amount of dry matter and nutrients. This was fed morning and evening, just after milking, with the feed ration sprinkled over it. In the second period, green rye fodder was fed instead of silage. The general herd was getting this forage and the cows under test showed uneasiness and discontent at seeing the other animals receive the green forage. Alfalfa hay was fed at noon. The amounts fed varied slightly, according to the appetite, weight of animal and amount of milk produced, care being taken to have no refuse left in the manger.

Average daily ration.... { 40 lbs. corn silage.
(40 lbs. rye fodder substituted in Period II.)
6 lbs. Alfalfa hay.
10 lbs. feed mixture.

Climax Grain Mixture.	Dried Brewers' Grains and Cottonseed Meal Mixture.
300 lbs. Climax grains.	225 lbs. dried brewers' grains.
300 " wheat bran.	225 " wheat bran.
	100 " cottonseed meal.

5 lbs. Climax grains. 5 " wheat bran.	Average daily amount fed	4.5 lbs. dried brewers' grains. 4.5 " wheat bran. 1 lb. cottonseed meal.

TABLE I.

Nutrients Consumed Daily.

KIND OF FOOD.	Total food consumed.	DIGESTIBLE NUTRIENTS. Protein.	Fat.	Carbohydrates.	Total (fat x 2.4).
Climax Grain Ration—	lbs.	lbs.	lbs.	lbs.	lbs.
Climax Grains	4.64	1.23	0.55	2.18	4.73
Wheat Bran	4.50	0.62	0.15	1.98	2.96
Corn Silage, 1st Period / Rye Fodder (Green), 2d Period	10.61	0.50	0.23	6.34	7.39
Alfalfa Hay	5.64	0.59	0.05	2.40	3.11
Total	25.39	2.94	0.98	12.90	18.19
Nutritive Ratio, 1:5.2.					
Dried Brewers' Grains and Cottonseed Meal Ration—					
Dried Brewers' Grains	4.12	0.71	0.23	1.68	2.89
Wheat Bran	4.05	0.56	0.14	1.78	2.67
Cottonseed Meal	.89	0.37	0.12	0.17	0.83
Corn Silage, 1st Period / Rye Fodder, 2d "	10.61	0.50	0.23	6.34	7.39
Alfalfa Hay	5.64	0.59	0.05	2.40	3.11
Total	25.31	2.73	0.77	12.32	16.89
Nutritive Ratio, 1:5.2.					

The rations have a slightly narrower ratio than was intended, due largely to the feeding of green rye fodder instead of silage in Period II., the green rye containing a higher percentage of protein. Table II. gives the composition of the different fodders and feeds.

TABLE II.

Composition of Feeds.

	Water.	Ash.	Protein.	Fiber.	Fat.	Nitrogen-free extract.
	%	%	%	%	%	%
Corn Silage	71.93	1.91	1.73	7.26	1.04	16.13
Rye Fodder	75.00	1.40	1.90	8.00	0.50	13.20
Alfalfa Hay	5.94	6.41	13 30	33.44	2.17	38.74
Climax Grains	5.08	2.52	34.59	10.60	11.54	35.67
Dried Brewers' Grains	8.20	3.60	19.90	11.00	5.60	51 70
Wheat Bran	10 00	6.40	16.00	10.00	4.60	53.00
Cottonseed Meal	8.20	7.20	42.30	5.60	13.10	23.60

Yield of Milk and Butter.

Table III. gives the daily milk yield for both periods, the fat test of the composite samples and the amount of fat produced. While the individual variations are noticeable, the records are on the whole quite uniform.

TABLE III.

Period I. — **Lot I.** Climax Grains, Wheat Bran Ration. — **Lot II.** Dried Brewers' Grains, Bran, Cottonseed Meal Ration.

DATE.	CHERRY.			ZOLA.			BUTTERCUP.			LILITH.		
	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.	Milk.	Fat	Fat.	Milk.	Fat.	Fat.
	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.
April 15	36.8	......	......	40.1	......	......	27.5	......	......	30.8	......	......
16	34.7	......	......	37.6	......	......	27.5	......	......	27.4	......	......
17	38.5	......	......	39.3	......	......	29.8	......	......	31.5	......	......
18	37.8	......	......	39.5	......	......	28.4	......	......	31.7	......	......
19	38.3	......	......	39.1	......	......	29.0	......	......	31.6	......	......
20	37.2	......	......	40.0	......	......	28.1	......	......	31.8	......	......
21	[illegible]	4.00	10.43	38.1	3.40	9.3[illegible]	26.0	3.9[illegible]	8.74	31.8	5.20	11.24
22	37.3	......	......	38.4	......	......	28.0	......	......	30.6	......	......
23	36.7	......	......	37.0	......	......	25.8	......	......	32.9	......	......
24	38.7	......	......	42.6	......	......	30.4	......	......	32.3	......	......
25	38.1	......	......	41.8	......	......	29.6	......	......	32.6	......	......
26	37.6	......	......	42.2	......	......	27.2	......	......	32.4	......	......
27	37.0	......	......	40.3	......	......	28.5	......	......	31.9	......	......
28	36.5	......	......	39.1	......	......	28.0	......	......	31.6	......	......
29	34.0	4.10	12.13	41.1	3.50	11.29	26.5	3.90	7.65	30.9	5.10	13.02
Total	556.7	......	22.56	596.2	......	20.60	420.3	......	16.39	471.3	......	24.26
Daily average	37.1	4.05	1.50	39.7	3.45	1.37	28.0	3.90	1.09	31.4	5.15	1.62

Period II. — **Lot II.** Dried Brewers' Grains, Bran, Cottonseed Meal Ration. — **Lot I.** Climax Grains, Wheat Bran.

DATE.	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.	Milk.	Fat	Fat.	Milk.	Fat.	Fat.
May 5	36.6	......	......	39.5	......	......	28.8	......	......	34.4	......	......
6	37.4	......	......	42.8	......	......	29.1	......	......	35.0	......	......
7	31.6	......	......	35.0	......	......	26.2	......	......	32.1	......	......
8	25.8	......	......	38.6	......	......	24.0	......	......	29.0	......	......
9	28.5	......	......	32.5	......	......	24.2	......	......	29.5	......	......
10	31.1	......	......	36.4	......	......	27.5	......	......	31.6	......	......
11	30.0	3.90	8.62	35.2	3.50	9.10	25.7	3.90	7.89	33.0	4.90	11.01
12	29.4	......	......	35.2	......	......	24.8	......	......	32.5	......	......
13	29.8	......	......	34.5	......	......	25.0	......	......	29.9	......	......
14	27.2	......	......	31.8	......	......	26.4	......	......	31.7	......	......
15	25.1	......	......	31.7	......	......	24.0	......	......	30.5	......	......
16	24.9	......	......	31.6	......	......	23.5	......	......	30.8	......	......
17	27.0	......	......	33.7	......	......	25.8	......	......	30.8	......	......
18	26.5	......	......	34.1	......	......	23.8	......	......	33.0	......	......
19	27.0	4.10	7.79	33.6	3.60	9.58	24.9	4.00	7.23	31.2	5.00	12.85
Total	410.9	......	16.41	526.2	......	18.68	382.7	......	15.12	471.5	......	23.36
Daily average	27.4	3.99	1.09	35.1	3.55	1.24	25.5	3.95	1.01	31.4	4.95	1.56

Table IV. gives a summary of results as recorded in Table III.

TABLE IV.

Summary of Experiment.

	RATION I. CLIMAX GRAINS AND WHEAT BRAN RATION.				RATION II. DRIED BREWERS' GRAINS, BRAN AND COTTONSEED MEAL RATION.			
	Milk.	Fat.	Fat.	Butter.	Milk.	Fat.	Fat.	Butter.
LOT I.	lbs.	%	lbs.	lbs.	lbs.	%	lbs.	lbs.
Cherry	556.7	4.05	22.56	26.32	410.9	3.99	16.41	19.15
Zola	596.2	3.45	20.60	24.03	526.3	3.55	18.69	21.81
Total	1,152.9	....	43.16	50.35	937.2	....	35.10	40.96
LOT II.								
Buttercup	382.7	3.95	15.12	17.64	420.3	3.90	16.39	19.12
Lilith	471.5	4.95	23.36	26.92	471.3	5.15	24.26	28.30
Total	854.2	....	38.48	44.56	891.6	....	40.65	47.42
Total	2,007.1	....	81.64	94.91	1,828.8	....	75.75	88.38
Daily average per cow	33.5	4.07	1.36	1.58	30.5	4.14	1.26	1.47

The total yield of milk and butter from the Climax Grains ration for the experiment was 2,007.1 pounds of milk and 94.91 pounds, respectively, with a daily average of 33.5 pounds of milk and 1.58 pounds of butter. The brewers' grains and cottonseed meal ration produced 1,828.8 pounds of milk and 88.38 pounds of butter, with a daily average of 30.5 pounds and 1.47 pounds, respectively, of milk and butter. There was a net gain of 178.3 pounds of milk and 6.5 pounds of butter from Ration I., or 8.8 per cent. and 6.9 per cent., respectively.

Cost of Rations and Production of Milk and Butter.

Table V. shows the cost of feeds for the two rations. The prices of the different feeds are arbitrary, but were about market prices at the time of the experiment.

TABLE V.

Cost of Rations.

	Pounds per day.	Total pounds consumed.	Price per ton.	Cost of ration.
Climax Grain Ration—				
Corn Silage, Period I	40.0	1,200	$3 00	$1 80
Rye Fodder, Period II	40.0	1,200	2 50	1 50
Alfalfa Hay	6.0	360	15 00	2 70
Climax Grains	5.0	300	26 00	3 90
Wheat Bran	5.0	300	22 00	3 30
Total cost	....	....	....	$13 20
Dried Brewers' Grains and Cottonseed Meal Ration—				
Corn Silage, Period I	40 0	12 00	3 00	$1 80
Rye Fodder, Period II	40.0	12.00	2 50	1 50
Alfalfa Hay	6 0	3 60	15 00	2 70
Dried Brewers' Grains	4.5	2.70	22 00	2 97
Wheat Bran	4.5	2.70	22 00	2 97
Cottonseed Meal	1.0	0.60	30 00	1 50
Total cost	....	....	....	$13 44

The prices of corn silage and green rye fodder are at cost of production, while alfalfa hay was figured at retail prices. As the cost of the forage, however, was the same in either ration, the difference in the cost of the rations varies according to the prices paid for purchased feeds. These were at retail prices at the time of the experiment.

As far as cost of rations is concerned, we see but little difference between the two rations; the brewers' grains and cottonseed meal ration costing but 24 cents more for a period of thirty days for two cows, or 0.4 cents per cow daily.

TABLE VI.

Yield and Cost of Milk and Butter Produced.

RATIONS.	Number of days.	Total cost of food.	Cost per cow, daily ration.	Daily yield of— Milk.	Daily yield of— Butter.	Cost to produce— Milk, per 100 lbs.	Cost to produce— Milk, per quart.	Cost to produce— Butter, per pound.	Net gain in cost of production— Milk.	Net gain in cost of production— Butter.	Net gain in cost of production— Milk.	Net gain in cost of production— Butter.
			cts.	lbs.	lbs.	cts.	cts.	cts.	cts	cts.	%	%
I. Climax Grains....	30	$13 20	22.0	35.6	1.58	62.0	1.33	13.92	11.4	1.32	15.5	8.6
II. Dried Brewers' Grains and Cottonseed Meal....	30	13 44	22.4	30.5	1.47	73.4	1.57	15.24	....	....	....	......

Table VI. gives us the cost of producing milk and butter from the two rations. Ration I., or the Climax Grains ration, produced milk at 62 cents per 100 pounds, and 1.33 cents per quart of milk, while 73.4 and 1.57 cents, respectively, per 100 pounds and per quart of milk, was the cost of Ration II. In nearly the same ratio, Ration I. produced butter at 13.92 cents, while Ration II. produced it at 14.24 cents per pound. The saving of cost, therefore, from the Climax Grains ration was 11.4 cents per 100 pounds, 24 cents per quart of milk and 1.32 cents per pound of butter. This is equivalent to a net gain of 15.5 per cent. and 8.6 per cent., respectively, for milk and butter.

TABLE VII.

Composition of Milk.

	Ration I.	Ration II.
Lot I.—	%	%
Cherry	4 05	3.99
Zola	3.45	3.55
Lot II.—		
Buttercup	3 95	3.90
Lilith	4 95	5.15
Average	4.10	4.15

Table VII. gives the average per cent. of fat of the two composite samples from each lot per period. The average, 4.10 per cent. and 4.15 per cent., respectively, for Rations I. and II. are the averages of percentages given in the table and vary slightly from the true average, 4.07 per cent. and 4.14 per cent., respectively, obtained by dividing the total amount of fat by the total amount of milk in the experiment. The difference is due, therefore, to variation in amounts of milk in making calculation for the total amount of fat.

The increase in percentage of fat from the Climax Grains ration, namely, 0.07 per cent., is slight, and a longer period of experiment should be made to determine whether this increase is abnormal, due to the shifting of the rations or the result due to the high percentage of fat distillers' grains contain. The results, however, are quite similar to results obtained at the Pennsylvania State Station* in a feeding test comparing distillers' grains with cottonseed meal.

* See Bulletin 73, by H. P. Armsby and A. K. Risser.

Weights of Animals.

The weights of the animals were taken at the beginning, middle and end of the experiment. Table VIII. gives the individual variation and average gain or loss in flesh from each ration.

TABLE VIII.

	CLIMAX GRAINS RATION.			DRIED BREWERS' GRAINS AND COTTONSEED MEAL RATION.		
	Beginning.	End.	Gain.	Beginning.	End.	Gain.
Lot I.—						
Cherry	775	1000	25	1000	990	—10
Zola	745	895	50	895	910	15
Lot II.—						
Buttercup	1040	1055	15	1050	1040	—10
Lilith	890	875	—15	860	890	30
Average Gain	....	....	75	....	....	25

While the results vary with individual animals, the total gain in flesh from feeding Climax Grains was seventy-five pounds, and twenty-five pounds from feeding the dried brewers' grains and cottonseed meal ration, or a net gain of fifty pounds from the Climax Grains ration.

Summary of the Results.

When substituted for four and one-half pounds of dried brewers' grains, four and one-half pounds of wheat bran and one pound of cottonseed meal, five pounds of bran and five pounds of Climax Grains produced:

1. A decided increase in yield of milk; the average daily gain per cow was 5.0 pounds, or 2.3 quarts.

2. A decrease in cost of production of milk and butter. The difference was 11.4 cents per 100 pounds of milk and 1.32 cents per pound of butter, or 15.5 per cent. and 8.6 per cent., respectively.

3. A slight change in the quality of milk. The per cent. of fat was increased 0.07 per cent. This may be due to the high percentage of digestible fat they contain.

II. FORAGE CROPS, 1905.

The season, on the whole, has been quite favorable to the growing of forage crops, except in June and July, when a spell of dry weather severely checked the growth of many, from which they never fully recovered. The crops suffering the most were those planted in freshly-worked fields, which allowed the heat to penetrate to a greater depth, where conservation of moisture was impossible and where the leaf evaporation was very great. Barnyard millet fulfilled these conditions and produced but one-third of its usual yield. Alfalfa is another crop which requires an unlimited water-supply and the best of soil conditions for the retention of moisture. The second cutting of alfalfa was a failure. The crown of the root, however, seemed to hold its vitality and quickly respond to the refreshing showers the latter part of July. Early-planted corn, on fields plowed the previous autumn and harrowed in the spring, suffered the least. The tendency was toward early maturity, low tasseling and smaller yield of forage. Corn which was planted late on soils reasonably moist outranked earlier planted fields in yield of both forage and seed. Some fields were affected by blight, which checked the maturity of ears and gave a large proportion of soft corn. Crimson clover was again a failure, being the second season in succession that it did not live through the winter.

The summer system of soiling followed here for several years was continued, and furnished the herd with an abundant supply of forage, except two weeks in July, when dry weather seemed to put all growth to a standstill. Fortunately there was a supply of silage left over May 1st, when summer forage crops began to be fed, and which helped over this emergency. Rye appeared in head at the usual time,

mentioned, twelve different kinds for forage crops gave a continuous rotation of green fodder to a herd of forty-five head of stock. The same method of feeding was followed, namely, the cutting, daily, of a ration of green forage and feeding morning and evening in a two-acre exercise yard. Table I. gives the amount of seed, date of planting, period of feeding, cost of seed, labor and fertilizers and yield of the forage crops fed. It will be noticed that a continuous supply of green forage was grown from May 1st to October 15th, except two weeks in July, when corn silage was substituted. This covered a period of 153 days, with an average cost of production of $1.93 per ton. Since several of the plots produced two crops of forage, and six acres produced second crops, used for other purposes than forage, in reality sixteen acres produced 197 tons, or an average of 12.3 tons per acre.

TABLE I.

Cost and Yield of Soiling Crops.

Acreage.	KIND.	Seed used per acre.	Date of seeding.	COST OF— Seed.	Labor.	Fertilizers.	Period of cutting and feeding.	Yield in tons.	Total cost.
		bu.							
2	Rye	2	Sept. 9-10.	$2 24	$8 10	$2 50	May 1-May 9.	7.98	$12 84
2	Rye	2	Oct. 1-3.	2 24	9 00	2 50	" 10- " 17.	11.25	13 74
1	Rye	2	" 10-12.	1 12	4 80	....	" 18- " 21.	4.48	5 92
2	Wheat and Winter Vetch	2-½	Sept. 9.	10 00	8 40	21 61	" 22-June 2	14.02	40 01
2	Wheat	2	Oct. 5-6.	4 60	7 20	....	June 3- " 6.	6.04	11 80
½	Alfalfa (first cutting)	.....	....	....	....	2 00	" 7- " 11.	3.63	2 00
2	Oats and Peas	2-1½	April 3.	5 80	8 10	13 57	" 12- " 20	15.80	27 47
2	Oats and Peas	2-1½	" 19.	5 80	8 70	4 14	" 21- " 29	14.00	18 64
1	Oats and Peas	2-¾	" 22.	8 30	3 90	2 07	" 30-July 4.	6.90	9 27
2	Oats and Vetch	1¾-¾	April 29-30.	5 82	7 20	13 12	July 5- " 7.	5.00	26 14
1	Oats and Vetch	1¾-¾	May 12-14	2 91	3 15	8 19	" 8- " 11.	5.00	14 25
6	Alfalfa (third cutting)	.....	....	....	....	3 75	" 12- " 14.	3.20	8 75
*	Corn Silage	.....	....	....	....	....	" 15- " 29.	13 00	59 00
2	Barnyard Millet	¾	May 4-5.	3 50	8 20	13 12	" 30-Aug. 3	4.30	24 82
1	White Flint Corn	12/32	" 8.	78	4 58	14 11	Aug. 4- " 10.	9.00	19 47
8	White Flint Corn	12/32	" 10-11.	2 34	13 72	42 83	" 11- " 31.	27.00	58 89
1	Cow Peas	1⅜	June 10.	3 19	3 00	5 06	Sept. 1-Sept. 6.	7.80	11 25
7/12	Kaffir Corn and Cow Peas	12/32-1	" 19.	1 40	4 83	1 99	" 7- " 10.	6.94	8 22
¼	Cow Peas	1½	" 15.	1 06	1 00	1 68	" 11- " 12.	2.60	3 74
2	Corn (different varieties)	12/32	May 10-15.	75	9 00	17 24	" 12- " 24.	18.00	26 99
1⅓	Cow Peas	1½	June 15.	3 57	5 33	3 20	" 25- " 29.	7.20	12 10
2	Cow Peas	1½	July 12.	5 50	5 40	4 12	" 30-Oct. 7.	8.45	15 02
1	White Flint Corn	12/32	" 19.	66	3 90	8 06	Oct. 8- " 13.	8.45	12 62
2	Alfalfa (fourth cutting)	.....	....	....	....	4 00	" 14- " 15.	2.00	4 00
	Totals	.....	....	....	....	....	158 days.	198.49	$362 45

Average cost of forage per ton, $1.93.

* Corn silage was not considered in finding the total yield and cost and period of feeding.

Crop Rotations.

The accompanying table gives some of the crop rotations. It is not confined to soiling crops entirely, nor does it give a record of the continuous summer supply. This data can be found in the preceding table. The object of the table was to show the total yield of forage and the total nutrients from individual plots, with the nutrients of clover hay, wheat bran and corn meal for comparison.

The arrangement includes one plot of corn used for silage; one plot of wheat and sand vetch, for the first crop, and a white flint corn, harvested as ears and dry fodder, for the second crop; one plot of alfalfa, harvested as hay, but its equivalent given as green forage. One plot of oats and vetch and one of millet, referred to under soiling crops, suffered from dry weather, which almost burned up the forage. Oats and peas, which began to mature when the dry weather began, produced fully an average yield. Plot V. yielded an excellent crop of corn, after one of wheat and sand vetch. The total protein from the plot was equal to that in five tons of clover hay, and the carbohydrates to that in seven tons of corn meal. Five plots gave an average yield of 14.8 tons of forage, equivalent in feeding value to almost three tons of clover hay each. Three plots gave an average yield of only 7.3 tons, equivalent to a little over one ton of clover hay each. Unfortunately, Plots IX. and X were very unprofitable, while Plot XII. (alfalfa) is much below the average.

TABLE III.

Crop Rotation.

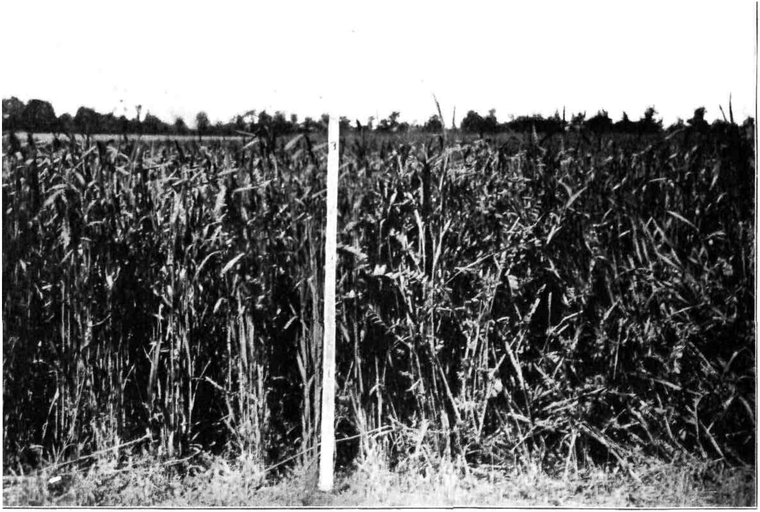
Plot.	KIND.	Yield per acre.	TOTAL NUTRIENTS. Protein.	Fat.	Carbohydrates.
		tons.	lbs.	lbs.	lbs.
	Rye	4.78	219.9	57.4	1,789.9
1	Oats and Vetch Seeded to Crimson Clover.	2.50	145.0	25.0	785.9
	Total	7.28	364.9	82.4	2,474.9
	Rye	6.45	296.7	77.4	2,347.8
2	Southern White Corn Seeded to Rye.	8.70	261.0	174.0	4,002.0
	Total	15.15	557.7	251.4	6,319.8
	Rye	4.48	203.8	53.2	1,612.5
3	White Flint Corn and Cow Peas Seeded to Wheat.	9.20	515.2	92.0	2,686.4
	Total	13.68	719.0	145.2	4,298.9
	Wheat	5.80	278.4	81.2	2,064.8
4	Kaffir Corn and Cow Peas Seeded to Wheat.	11.08	485.3	132.4	3,066.3
	Total	16.88	763.7	213.6	5,131.1
	Wheat and Winter Vetch	7.10	454.4	71.0	1,945.4
	White Flint Corn (ears) bush.	98.7	384.9	137.9	2,818.2
5	" " " " (soft) bush.	10.0	84.0	14.0	285.6
	" " " " Fodder (dry) Seeded to Crimson Clover.	5.6	425.6	168.0	6,008.2
	Total	....	1,245.9	390.9	11,047.4

TABLE III.—Continued.

Crop Rotation.

Plot.	KIND.	Yield per acre.	TOTAL NUTRIENTS. Protein.	Fat.	Carbohydrates.
		tons.	lbs.	lbs.	lbs.
6	Oats and Peas Seeded to Alfalfa.	7.40	296.0	103.6	2,397.6
7	Oats and Peas	7.00	280.0	98.0	2,268.0
	Cow Peas	6.74	417.8	94.4	1,617.6
	Total	13.74	697.8	192.4	3,885.6
8	Oats and Peas	6.15	246.0	86.1	1,992.6
	White Flint Corn	8.45	287.3	101.4	2,788.5
	Total	14.60	533.3	187.5	4,781.1
9	Barnyard Millet Seeded to Grass.	2.15	64.5	25.8	627.8
10	Oats and Vetch Seeded to Grass.	4.69	271.0	46.9	1,878.9
11	Cow Peas. Seeded to Grass.	7.30	452.6	102.2	1,752.0
12	Alfalfa	12	1,080.0	216.0	4,178.6
13	Southern White (ensiled)	10	300.0	200.0	4,600.0

	Protein.	Fat.	Carbohydrates.
Four tons Clover Hay contains	948	184	5,648
Three " " " "	738	138	4,236
Two " " " "	492	92	2,824
Three " Wheat Bran "	960	276	3,732
Three " Corn Meal "	540	246	4,362



1905. Wheat and Sand or Winter Vetch. Yield, 7.10 Tons per Acre.

hardens when maturing and its feeding value as rapidly diminishes—thus the reason for different plantings, beginning to feed when the first heads appear. It is generally economical to be liberal with seed, broadcasting with a drill or by hand. Fully as good results have been obtained by working the soil with a disk harrow instead of plowing. Rye can also be sown as a cover crop in corn, at the last cultivation.

Wheat.—This crop usually succeeds rye and makes a more desirable forage. When sowed even as late as October it passed the winter well and produced an average yield of forage, namely, six tons per acre. It was drilled at the rate of two bushels per acre. Top-dressing with manure, in the fall, or with nitrogenous fertilizers, such as nitrate of soda, in the spring, is desirable, to which the crop quickly responds.

Wheat and Sand, or Winter Vetch.—Sand vetch is an annual plant, a legume, and is grown in many places as a cover-crop. Because of its highly nitrogenous character and its ability to utilize atmospheric nitrogen, an experiment was conducted to study its value as a forage crop, planting with wheat. Two acres were seeded September 9th, 1904, using at the rate of two bushels of wheat to one-half bushel (thirty pounds) of sand vetch per acre. The field gas given a good dressing of stable manure and about 200 pounds of fertilizer were drilled with the seed. The vetch started slowly, made but little growth at first, but the following spring seemed to attain more vigor, with encouraging results.

The combined forage, when cut, was greatly relished by the cattle; was of excellent quality, yielding seven tons per acre. This was one ton more than a crop of purely wheat forage, raised under similar conditions. Wheat at $1.15 per bushel, and vetch at $9 for 100 pounds, made the cost of seed, per acre, $5, and, including labor and fertilizers, made the cost of forage, per ton, $2.85. It is doubtful, therefore, even with the slightly increased yield and quality, whether it is economical for the farmer to grow sand vetch at the present prices for seed.

Crimson Clover.—The crop was a failure this season, as the plants winter-killed. We attribute the reason, partly, to severe cold weather, with very little snow for protection the latter part of the winter, and partly to the conditions under which it was grown, namely, as a cover crop, in cow peas and Kaffir corn. The nurse crop produced too much shade, making the plants spindling, with insufficient root surface to endure the cold weather.

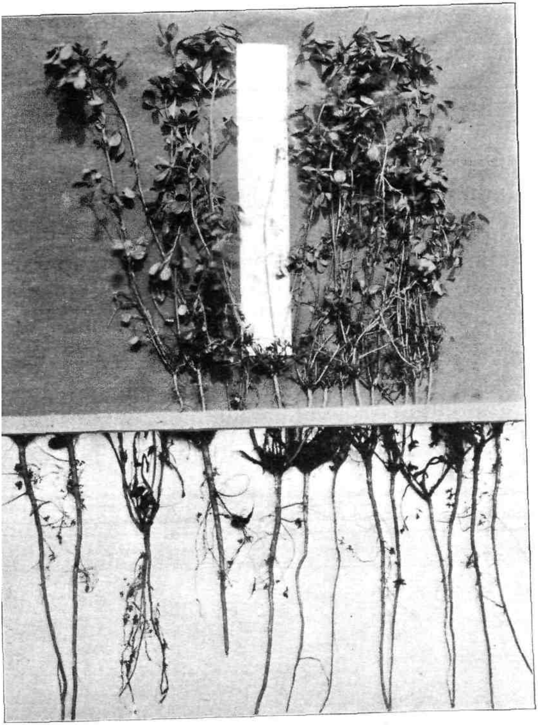
Alfalfa.—The present season has been quite unfavorable in this vicinity for alfalfa. That the crop can be successfully grown is evident from our own experience in previous years, and from the reports from farmers in different sections of the State who are growing the crop upon our recommendation. There are many things yet to be learned regarding its culture. That some are successful in raising it, while others fail, where the same methods were employed, is hard to explain. In some cases we have positive evidence that the soil lacked in the tubercle bacteria; in others we find the bacteria abundant, yet the plants turned yellow gradually, thinning out and dying.

EXPERIMENT WITH INOCULATION.

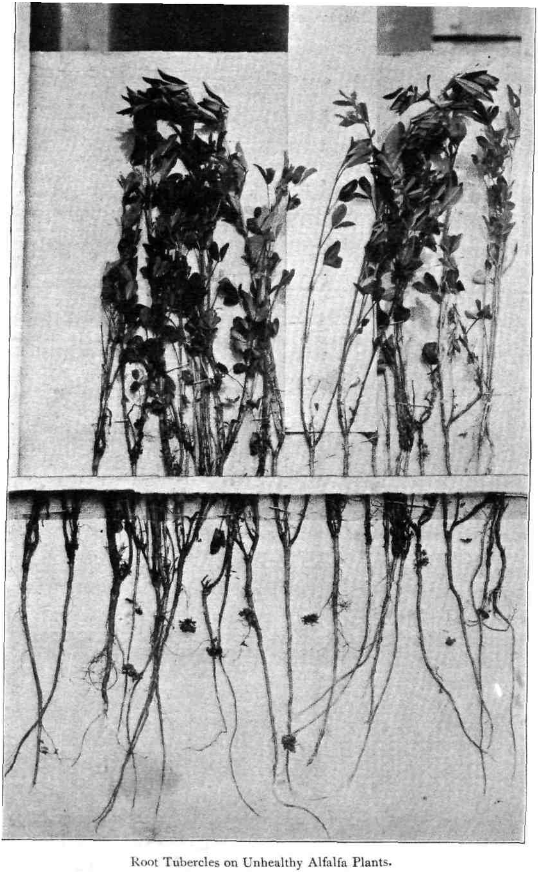
An experiment was started last season to study the subject of inoculation, and to see if the bacteria which inhabit the tubercles on the sweet clover, which is so common in many places along the roadside and vacant lots, is the same as the bacteria inhabiting the tubercles on alfalfa, and whether the soil taken from sweet clover fields can be used for inoculating new fields of alfalfa. The experiment, as far as inoculating is concerned, has not been fully successful, as seasonal conditions entered in to disturb the comparison of plots and the calculation of results of yield. Nevertheless, certain very interesting features have developed which are worthy of mention.

Plan of Experiment.

The field was rolling, gently sloping from the east, west and south towards the center and north. The soil is a red shale, with a considerable portion of clay, having a tendency to harden and bake in dry weather. On the slopes and knolls the soil was thin, and the fertility partially washed away. In the fall of 1903 a dressing of stable manure was applied, and the spring following the land was plowed, well prepared and seeded to oats and peas. The crop produced a good yield and left the ground very free from weeds. The field was now plowed and allowed to lie fallow through July, occasionally harrowing to keep down the weeds. Early in August the surface was finely pulverized and 200 pounds of oyster shell lime and about 300 pounds of fertilizer, mostly mineral, were applied.



Root Tubercles on Healthy Alfalfa Plants



Root Tubercles on Unhealthy Alfalfa Plants.

C

The field was now divided into four plots, and inoculating material was applied as follows:

Plot I. 450 lbs. soil from old alfalfa field.
" II. 450 " soil from a field of sweet clover.
" III. No inoculation; a check plot.
" IV. Inoculated the previous year.

Thirty pounds of seed were sown per acre. Just after Plots III. and IV. were seeded, August 19th, a tremendous shower occurred, badly washing the field, the little rivulets making ruts in some places, and the finer soil from slopes was carried to the lower portions of the field. Plots I. and II. had to be refitted and were seeded three days later. Soon after this a second shower came, even harder than the first, which again badly washed the field. The result was that again much of the fertility applied was carried to the lower parts of the field, and even off from it altogether, covering the seed too deeply in some places, leaving it too thin in others. When the new plants appeared the distribution was much evener than was expected, though bare, apparently on badly-washed spots. These spots were reseeded, even though it was late, and about December 1st the whole field was top-dressed with ten tons of barnyard manure per acre.

Results in 1905.

Early in May careful examination of the roots on all plots showed the presence of the characteristic tubercle, even as abundantly on Plot *III., that received no inoculating material, as on the others.* It showed the probability that the heavy rains washed some of the material from Plots I. and II. on to Plot III., which was unfortunately in a position to receive the washings. The results of the yields of hay from the first cutting showed as large or even larger yield on the plot not inoculated with soil.

About May 10th the plants on some portions of the slopes and higher ground began to turn yellow, have a sickly color, and the growth was checked. This was especially noticeable on one-half of Plot I., on Plot II. and some portions of Plot III., where the field had lost the finer portions of soil by washing. Examination of the roots showed the presence of tubercles everywhere, but more abundant where the soil was deeper and the foliage was green and thrifty. Furthermore, in the yellow spots the tubercles where found were in clusters or aggre-

gate of masses and very compact, some being even larger in size than a bean. Where the plants were green the tubercles were more scattered, single and very abundant.

The two forms were examined by the Station bacteriologist, who found more of the branched forms of bacteria, or bacteriods, as they are called, where the tubercles were found in masses. These bacteriods are usually found on healthy, vigorous plants; yet, on the contrary, in this case they seemed abundant on the sickly ones. It is evident, therefore, that the result was not due to a lack of nitrogen, proved also by an application of nitrate of soda at the rate of 100 pounds per acre, which seemed to have no beneficial effect on the plants.

The clustering or massing of the tubercles may be due to: (1) ventilation; (2) acidity of soil, or (3) different bacteria entering in to influence the form of tubercle. By ventilation is meant the porosity of the soil—compact clay soil will not allow the oxygen to penetrate freely. The condition suggests greater acidity, because it has been found in the laboratory that the branched forms of bacteria can be produced artificially only in a culture slightly acid.

The effect of lime on soils in reducing the acidity, influencing the physical conditions and assisting the retention of moisture, is shown by other results, namely, a strip three rods wide across the end of three plots, which had some years ago a heavy application of lime, produced thrifty, green foliage in marked contrast to alfalfa growing near it. Also, a portion of Plot IV., one-quarter acre, which received no lime in an experiment the previous year, showed a lack of vigor and green color in the plant and produced not over one-half to two-thirds as much alfalfa hay as other portions of the same plot.

While it is impossible to give definite conclusions until more experiment work has been done along this line, certain methods in the preparation of the soil may be suggested:

Suggestions.

1. The incorporation of organic matter in the soil some time previous to seeding, by a liberal application of barnyard manure, or turning under a crop of green manure.

2. An application of at least 2,000 pounds of stonelime (twenty-five bushels) at the time of seeding, or preferably 2,000 pounds of stonelime the year or two previous, and 1,200 pounds at the time of seeding.

Selection of Seed.

It is very important that the best seed be purchased. It is cheapest in the end. Even if this is done, there are two things to watch out for—first, that the seed is free from dodder. It is a parasitic plant, having no leaves and appears as fine yellow stems, winding about and clinging to other plants. After the dodder seed germinate the root soon dies, but the stems live, thriving on the juices of the host plant. It is very destructive to alfalfa whenever it gets a foothold, and as soon as discovered the spot should be cut over and burned. This can easily be accomplished with the aid of straw or similar material.

In this country, thus far, blight has given us very little trouble. It has been said, however, that in some parts of Europe it is impossible to raise alfalfa because of the plant diseases.

In August of this year the best seed, as we thought, was purchased and sowed on six acres of land. It looked bright and plump, comparatively free from adulteration and germinated well. The new seeding looked remarkably well up to October 1st, when it began to have the appearance of being affected by frost. The disease first attacked the leaves, then the stems, and at present writing, November 10th, the plants on the entire six acres are apparently dead.

CYLINDER EXPERIMENTS WITH LIME.

The application of lime for leguminous crops, clovers, alfalfa, peas and beans is now recognized as a necessity, in order to neutralize the acidity of the soil, promote the best development of beneficial bacteria and render the plant-food more available. The object of the experiment was to learn what effect different applications of lime at the time of seeding alfalfa had upon the growth and yield of the crop.

Plan of Experiment.

Soils from different portions of the State, varying widely in character, which were used in a previous experiment, were selected for this test, and the same cylinder method adopted. The method of taking the soil, placing in cylinders and diagram of experiment plot is described in detail in that report.* The soils used are:

* See page 367, Experiment Station Report, 1903.

1. Heavy loam, in marl area, Freehold, Monmouth county.
2. Limestone, Augusta, Sussex county.
3. Red shale, New Brunswick, Middlesex county.
4. Sandy, Woodbine, Cape May county.
5. Heavy clay, Woodstown, Salem county.
6. Glacial drift, Oakland, Bergen county.

There were nine cylinders of each kind of soil except the New Brunswick red shale, which had fifteen—nine with College Farm and six from the old alfalfa field, on which this crop had been grown since 1898. There were also but three cylinders of Bergen county glacial drift soil. The experiment was divided into three series, each series having three cylinders each of heavy loam, limestone, sandy and heavy clay soils, five of red shale and one of glacial drift. Series I. received at the rate of 2,200 pounds per acre of stonelime, freshly slaked and applied in the caustic condition. Series II. received an application of 1,100 pounds per acre, while Series III. received no lime at the time of seeding. In 1903, when the inoculation experiment was established, each cylinder received prepared lime at the rate of 1,180 pounds per acre. Also, at the close of the season of 1904, tubercles were found on the alfalfa roots of all of the series of cylinders; therefore it was not necessary to reinoculate the soil.

Fertilizers.

There was also an experiment to test the influence of different fertilizers. This was also divided in three series running crossways of the lime experiment series, and did not interfere in any way with the results of that experiment. The fertilizers applied, and results from it, will be treated under another topic.

Seeding.

The surface area of each cylinder was computed, and the amounts of lime and fertilizer applied to each was calculated on acre basis. Sixty seeds were planted in each cylinder June 6th. The season was very dry in midsummer, so that but two cuttings were made, namely, July 25th and September 12th. The yield per series of cylinders for each soil is expressed in the following tabulation:

TABLE IV.

Results of Experiment.

Character of Soil.	Series I. At rate of 2,200 lbs. lime per acre.		Series II. At rate of 1,100 lbs. lime per acre.		Series III. No lime.	
	First cutting.	Second cutting.	First cutting.	Second cutting.	First cutting.	Second cutting.
	grams.	*grams.*	*grams.*	*grams.*	*grams.*	*grams.*
1. Heavy Loam, 3 cylinders each Series......	69	52	56	33	40	28
2. *Limestone,* 3 " " "	67	76	63	50	50	31
3. Red Shale, 5 " " "	107	96	94	65	73	57
4. Sandy, 3 " " "	63	49	63	76	60	64
5. Heavy Clay, 3 " " "	74	55	67	49	67	58
6. Glacial Drift, 1 " " "	19	11	19	10	17	5
Total..........	399	339	362	283	307	238
Total for each Series..........	738		645		545	

In June and July the cylinders were watered whenever necessary, precautions being taken to give equal measurement of water to each cylinder. In the latter part of the summer the weather was cooler, with more frequent rains, and the second cutting produced a lighter yield. The gain or loss in yield is tabulated in Table V.

TABLE V.

Gain or Loss in Grams and Per Cent. Per Acre.

FIRST AND SECOND CUTTINGS.

CHARACTER OF SOIL.	GAIN. 2,200 LBS LIME OVER NO LIME.				GAIN. 1,100 LBS. LIME OVER NO LIME.				GAIN. 2,200 LBS. LIME OVER 1,100 LBS. LIME.			
	FIRST CUTTING.		SECOND CUTTING.		FIRST CUTTING.		SECOND CUTTING.		FIRST CUTTING.		SECOND CUTTING.	
	Grams.	Per cent.	Grams.	Per cent.	Grams.	Per cent.	Grams	Per cent.	Grams.	Per cent.	Grams.	Per cent.
1. Heavy Loam	29	42.0	24	46.4	16	28.6	5	15.1	13	18.8	19	36.5
2. Limestone	17	25.4	45	58.0	13	20.6	19	38.0	4	6.0	26	34.2
3. Red Shale	34	38.8	39	40.6	21	22.8	8	12.8	13	12.1	31	32.2
4. Sandy	3	4.7	−15	−28.4	3	4.7	12	15.7	.....	....	−27	−35.5
5. Heavy Clay	7	9.4	2	8.6	.....	....	−4	7.6	7	9.4	6	10.9
6. Glacial Drift	2	10.5	6	51.5	2	10.5	5	50.0	.....	....	1	9.1

Table VI. gives the gains in yield from the limed cylinders for the season. In comparing the first and second cuttings with the total yield for the season, while there was some variation between cylinders, the results were comparatively uniform, and show the influence of lime to a marked degree.

TABLE VI.

Gain or Loss in Grams and Per Cent. Per Acre.

TOTAL YIELD.

CHARACTER OF SOIL.	GAIN. 2,200 LBS. LIME OVER NO LIME.		GAIN. 1,100 LBS. LIME OVER NO LIME.		GAIN. 2,200 LBS LIME OVER 1,100 LBS. LIME.	
	Grams.	Per cent.	Grams.	Per cent.	Grams.	Per cent.
1. Heavy Loam	53	48.8	21	23.6	32	26.4
2. Limestone	62	48.8	32	28.3	30	21.0
3. Red Shale	73	36.0	29	18.2	44	21.6
4. Sandy	—12	—9.7	15	10.8	—27	—19.4
5. Heavy Clay	9	7.0	—4	—3.8	13	10.1
6. Glacial Drift	8	26.6	7	24.1	1	3.3
Total	193	....	100	....	93	....
Average	....	26.1	....	15.5	....	12.6

Comparing the total yield from Series I., II. and III., it is found that a gain of 26.1 per cent. was produced from an application of stonelime at the rate of 2,200 pounds per acre, 15.5 per cent. from an application of 1,100 pounds per acre, while there was 12.6 per cent. greater yield where 2,200 pounds were applied than where the plots received 1,100 pounds of stonelime per acre. These results are certainly suggestive.

Comparing the yield from the different groups of soil, it is noticeable that there is a wide difference. They were benefited by applications of lime in the following order:

1. Augusta limestone.
2. Freehold marl.
3. New Brunswick red shale.
4. Oakland glacial drift.
5. Woodstown heavy clay.
6. Woodbine sand.

It would be expected that lime would have the least beneficial effect on sand, but a more marked result would be expected from a heavy clay. The physical condition of this soil may partly explain the reason. The soil was very compact and not so suitable for alfalfa. A continuation of this experiment another year will be interesting.

Fertilizers for Alfalfa.

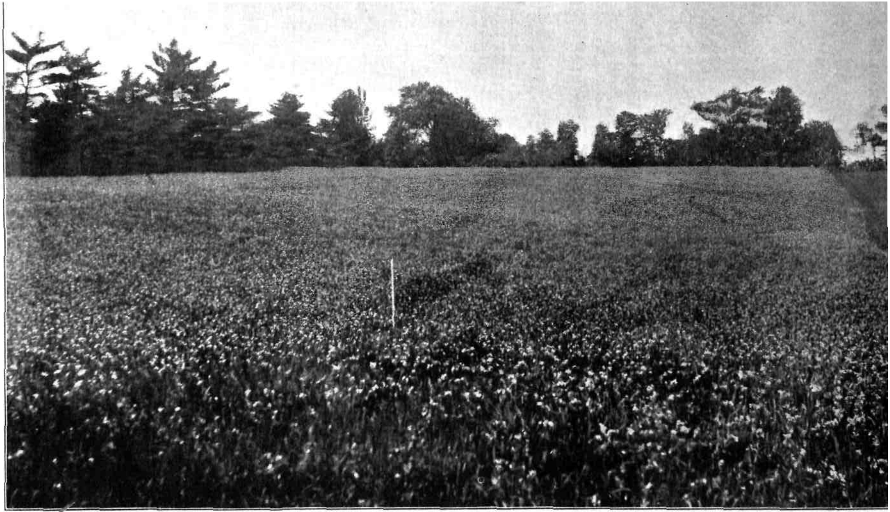
In the previous lime experiment the cylinders were arranged in checks, so that the rows running across the plot could also be divided into three series, allowing three cylinders of each kind of soil for each series. Another experiment, therefore, could be carried on without interfering. It was decided to apply fertilizer in three different proportions. Series I. would receive nitrogen, phosphoric acid and potash; Series II. would receive the same amount of phosphoric acid and potash, but no nitrogen; while Series III. no nitrogen, but a larger amount of phosphoric acid and potash than Series II. The amounts applied, per acre, are as follows:

	Series I. lbs.	Series II. lbs.	Series III. lbs.
Nitrate of Soda	75	...	...
Plain Superphosphate	200	200	300
Muriate of Potash	150	150	200
Total	425	350	500

Results.

From the total yield on the groups of soil it was found that the application of nitrate of soda was of no advantage in the months of June, July and August. It may possibly be of assistance for early spring or late fall seeding to give the young alfalfa plant a start. Second, that the larger application of phosphoric acid and potash, namely, 300 pounds of acid phosphate and 200 pounds of muriate of potash, gave an increased yield of only 4.1 per cent.

Peas and Oats.—Peas and oats is a crop the dairy farmers mostly depend upon in June for summer forage. Coming in a rotation between the first and second cuttings of alfalfa, or after wheat and crimson clover, it furnishes an abundance of highly nutritious food, and is in itself almost a balanced ration. Furthermore, it allows sufficient time for the growing of a second crop on the same field of



Oat and Pea Forage, 1905. Yield, 7.40 Tons per Acre.

1904. Oats and Spring Vetch. Yield, 7.50 Tons per Acre.

millet, cow peas, soy beans or even corn. It should be planted early, preferably before April 15th in this section, to allow the crop to get well established before hot weather comes. Later plantings have a tendency to blight or to be affected with lice. The amount of seed should be liberal—at least two bushels of oats to one and one-half bushels of Canada peas—and the soil should be well prepared. Plowing the previous fall and working well with a disk harrow in the spring is desirable.

The crop this season produced an excellent yield of seven and one-half to eight tons per acre of green fodder, and the forage was three feet tall before the heads appeared. One plot, planted April 22d and cut June 29th to July 4th, was refitted, planted to Thoroughbred White Flint corn, July 19th, and produced a yield of 8.25 tons of forage per acre.

Oats and Vetch.—This crop can follow oats and peas, and supply forage before millet, cow peas or second crop of alfalfa is ready. Although often producing not quite as large a yield as oats and peas, it has the advantage of not being as easily susceptible to mildews and insect enemies. Vetches thrive best, however, when there is an abundance of moisture. This season the drought in June and early part of July greatly influenced its growth and the yield was light. Seed at the rate of one and one-half to two bushels of oats and one-half bushel of spring vetch per acre.

Millets.—Of the several varieties known, the Japanese variety known as barnyard millet is one of the best for soiling purposes: (1) Because of its succulency and greater percentage of dry matter; (2) rapid growth, often maturing from forty-five to fifty days, and yielding an average of ten tons per acre—in 1903 a yield of 13.6 tons per acre was secured; (3) greater range of seasons. It can be planted as early as corn, or as a second crop late in the season. Seed at the rate of three pecks per acre.

Thoroughbred White Flint Corn.—This is one of the best varieties of corn for soiling purposes because of its earliness, its stooling characteristic producing an abundance of forage, with a large proportion of ears and dry matter. It can be planted early in May and will be mature for cutting July 25th to August 1st. The yield is from nine to fifteen tons, according to the conditions of soil and season. One planting, made July 19th, yielded 8.25 tons per acre. It produces long, sound ears, two acres this season yielding ninety-eight bushels of ears and five tons of field-cured stover per acre.

Kaffir Corn and Cow Peas.—This crop, from a standpoint of yield, content of dry matter, palatability and nutritive value, has been found very valuable for summer soiling. It can be planted after the first week of June as late as the 1st of August, maturing from sixty to seventy-five days, according to the season. This combination is better suited for soiling than millet and cow peas from the fact that the Kaffir corn and cow peas mature about the same time.

Twelve quarts of Kaffir corn to one and one-fourth bushels of cow peas per acre, broadcasted, has been found sufficient, and the yield this season was 11.3 tons per acre. Since the yield averages nearly that of corn, a portion of the crop this season was put into the silo to see if it cannot be used economically for that purpose.

Cow Peas.—This crop enters the soiling rotation about August 15th, depending upon the season. Its value as a crop is threefold, namely: (1) Producing a nitrogenous and very palatable fodder; (2) with a little care it can be harvested as hay, almost equaling alfalfa in milk production and largely replacing the purchased feeds in the ration; (3) because of its ability to utilize atmospheric nitrogen, and thus enrich the soil.

In raising cow peas for forage, the method of harvesting should be considered. Where only a small plot is grown, and the vines are pulled, the long-trailing varieties can be grown; but where the crop is cut with a mower, the long vines cause annoyance and considerable of the crop is left on the field. Another thing to consider is whether an early or late-maturing crop is desired. Where cow peas are planted with corn, as is the practice with some, the early varieties mature much earlier than the corn. A system which has been followed here can be recommended, namely, to plant a late-maturing cow pea when the corn is about four inches high. This can be easily done with a corn-planter, letting the machine run three inches one side of the row. If the wheel passes over the row, little danger need be feared, as the corn very quickly assumes its erect position. For this purpose, also, the variety Red Ripper, because of its late-maturing habit and erect manner of growing, is to be recommended. Of the early to medium varieties, the Small Black, Early Black, Taylor, New Era and Warren's New Hybrid, which are also medium trailers, are to be recommended. Of the erect late varieties, the Red Ripper, Clay, and a new medium-trailing variety, Iron, are to be recommended.

When sowed broadcast, drill one and one-half bushels per acre,

Kaffir Corn and Cow Peas. 11.3 Tons per Acre.

or about three pecks per acre in rows two and one-half feet apart. On new fields it may be necessary to inoculate from some other field, but where the field has been well manured it is quite probable that the bacteria are already present.

VARIETY TESTS WITH COW PEAS.

Nine varieties of cow peas were sent from Washington, D. C., for testing in respect to (1) hardiness, (2) yield of forage, (3) yield of seed. Two new varieties which were tried last season were again planted in order to further study their value as forage crops in comparison with other varieties. The varieties tested were as follows:

1. Early Black.
2. Large Blackeye.
3. California Blackeye.
4. Clay.
5. Unknown or Wonderful.
6. Warren's Extra Early.
7. Taylor.
8. New Era.
9. Warren's New Hybrid.
10. Iron.
11. Michigan Favorite.
12. Small Black.

Field Notes.

The cow peas were planted on a new field purchased by the College late in the spring. The land had been cropped for several years, the elements of fertility taken off with but very little added. Careless cultivation had brought in a large number of weeds of all kinds. This season's cultivation, therefore, was expensive, as vigorous measures had to be adopted to eradicate the weeds. No manure was applied, and a complete fertilizer, at the rate of 200 pounds per acre, cultivated in after the crop was planted, was all the plant-food supplied. The soil was a red shale, with enough sand to make it friable and suitable for cow peas. The season was quite favorable—in fact, it was exceptional for the maturing of the crop, and seed was secured from some varieties which would not have matured in ordinary seasons. The seed was sown in drills two and one-half feet apart, at the rate of about three pecks per acre, and the ground was cultivated regularly.

Early Black.—A little uneven in the early part of the season. It began to vine early, trailing three to four feet in length by August 21st. The pods were long, well filled and the forage kept green until September 30th.

Large Black Eye.—More adapted for forage than for seed. The vines were quite prostrate, trailing three to five feet in length. This fact makes the variety not so desirable where the green forage is cut with a machine. The pods, while long, were in many instances but half filled.

California Black Eye.—Of the two varieties of Black Eyes, this one seemed to be the most desirable for seed production. The kernel is smaller; therefore, more economical in purchasing. As a forage crop it does not hold a high rank because of lighter yield and trailing character. Like the other Black Eye variety, the pods were not well filled.

Clay.—This kind is too late a variety to mature seed. The erect manner of growing and its generally vigorous and thrifty nature commends it for soiling purposes. The yield of green forage was 8.3 tons per acre, the largest yield of any variety tested.

Unknown, or Wonderful.—A late variety, and will mature seed in this latitude only in very favorable seasons. Its bright, waxy color and thrifty habit of growing makes a very showy appearance. But very little seed was obtained, and that of inferior quality.

Warren's Extra Early.—A variety which will mature early—the forage is ready for cutting sixty days from planting—and which will mature seed in ninety-five days. Especially to be recommended for seed, it yielding eleven bushels per acre.

Taylor.—The amount of seed furnished was insufficient to obtain the yield of green forage per acre. The vines were very thrifty and well filled, and while a little late will mature seed in ordinary seasons.

New Era.—Desirable to grow for seed or for forage, yielding at the rate of 14.1 bushels of seed or 7.3 tons of fodder per acre. Its semi-erect habit is also a point to be considered if desired for soiling.

Warren's New Hybrid.—The earliest of all varieties tested, as well as producing the greatest yield of seed, namely, at the rate of 13.3 bushels per acre. It is especially recommended to be grown for seed, as its trailing habit makes it hard to harvest green.

Iron.—This is the second season that this variety has been grown here. It was intended to raise the seed, but as the field upon which it grew was to be seeded to grass only the yield of forage was determined, namely, 8.1 tons per acre. The character of the plant was much more erect, with fewer trailers than last season. It is very vigorous, hardy, and, on the whole, a commendable variety.

COW PEAS.

Warren's Extra Early. Unknown. Clay.

TABLE VII.

VARIETY.	Date of seeding.	Rows planted.	Part of acre.	NUMBER DAYS AFTER PLANTING. Vines began to trail.	Vines began to blossom.	Pods appeared.	Seed matured.	YIELD PER ACRE. Green forage.	Seed.	Character.
	1905.							tons.	bush.	
Early Black	June 15.	6	.1032	49	65	73	105	5.5	10.0	Trailing.
Large Blackeye	"	5	.0860	42	75	80	110	7.5	4.8	"
California Blackeye	"	4	.0688	47	60	68	100	5.8	8.0	"
Clay	"	5	.0860	erect.	95	110	....	8.3	....	Erect.
Unknown	"	8	.0516	erect.	80	95	182	7.0	1.0	Semi-erect.
Warren's Extra Early	"	5	.0860	46	55	60	95	6.5	11.0	"
Taylor	"	1	.0172	50	68	75	115	....	11.5	Semi-trailing.
New Era	"	5	.0860	70	60	67	110	7.8	10.0	Semi-erect.
Warren's New Hybrid	"	5	.0860	45	50	60	90	6.9	13.8	Semi-trailing.
Iron	" 10.	drilled.	.2800	60	71	80	harvest'd green.	8.1	....	Semi-erect.
Michigan Favorite	"	"	.1400	50	75	85	"	6.8	....	Semi-trailing.
Small Black	"	"	.3800	48	70	80	"	5.8	....	Trailing.
Average yield	....	....	?	....	....	....	....	6.9	8.7	

Trailing—vines long, 4-5 feet Semi-trailing—vines medium, 2-3 feet. Semi-erect—vines short, 1-2 feet. Erect—no vines.

Michigan Favorite.—A less vigorous grower, a large proportion of seed not germinating. After the year's trial the results were inferior to many other varieties. The seed was not allowed to mature for the same reason as mentioned under previous variety.

Small Black.—The yield, namely, 5.8 tons, was below what it would have been if the mower could have done better work. The seed was not allowed to mature. It is a thrifty and vigorous grower, and where the vines are pulled probably very good results can be obtained.

Table VII. gives a summary of the results.

VARIETY TESTS WITH SOY BEANS.

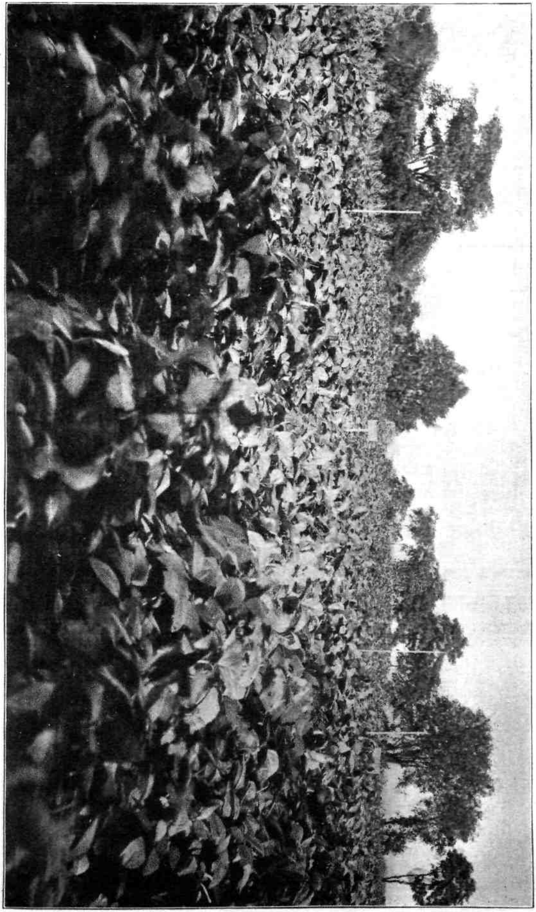
The seed of four varieties, namely, Early Black, Medium Yellow, No. 12400, Medium Yellow, No. 12399, and Light Medium Green, were received from the Department of Agriculture, Washington, D. C., and planted June 15th, on a plot adjoining the plot of cow peas. Nine rows, two and one-half feet apart, of Early Black, were considered equivalent to three rows, well stocked, as the machine used in planting them did not drop them so thickly; some, also, did not germinate. The field notes of this experiment are as follows:

Early Black.—Forage short, two feet six inches high, yielding at the rate of only 4.7 tons green forage. Pods thickly clustered on stalk; seed large. Yield, 16.5 bushels per acre.

Medium Yellow, No. 12399.—Forage 3.5 feet tall; vigorous; matures seed in 100 days. Yield of forage, 6.2 tons per acre; seed at the rate of 24.5 bushels per acre.

Medium Yellow, No. 12400.—Forage not as tall as the other variety and the stem has a different system of branching. It was three feet tall, vigorous and thrifty. Yield of forage, 3.9 tons; seed, 21.5 bushels per acre.

Light Medium Green.—Forage three feet six inches tall, filling the rows; vigorous and a quick grower; matured seed in about 100 days. Yield of forage, 4.9 tons; seed, nineteen bushels per acre.



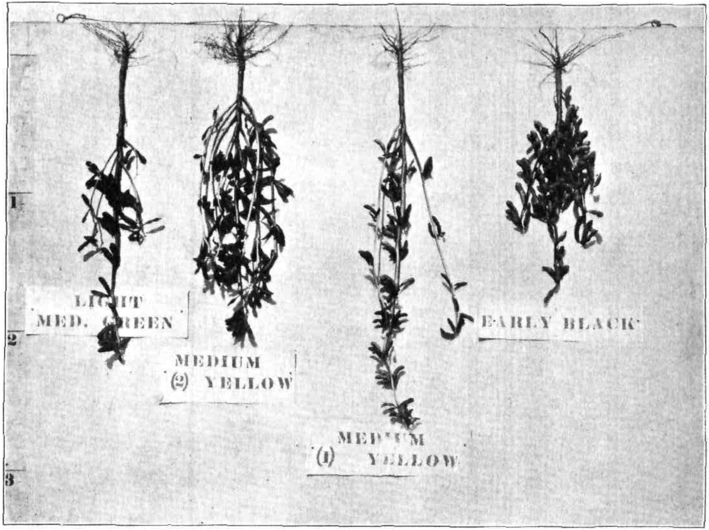

MED.
MEDIUM
(2) YELLOW
(1) YELLOW
EARLY BLACK
1
2
3

TABLE VIII.

VARIETY.	Date of seeding.	Rows planted.	Part of acre.	NUMBER DAYS AFTER PLANTING. Blossoms appeared.	Pods appeared.	Seed matured.	YIELD PER ACRE. Green forage.	Seed.
							tons.	bush.
Early Black	June 15.	9	.1548	50	60	80	4.7	16.5
Medium Yellow, No. 12,399	"	6	.1032	52	65	100	6.9	24.5
" " No. 12,400	"	8	.1376	50	61	100	3.9	21.5
Light Medium Green	"	6	.1082	55	62	105	4.9	19.0
							5.1	20.4

OATS AND PEA HAY.

A ten-acre field, on which corn had been grown for several seasons in succession, was fitted and planted to oats and peas April 14th and 15th. Six acres were plowed last November and worked with a disk harrow this spring. The amount of seed used was two bushels of white oats and one and one-half bushels of Canada peas, variety Golden Vine.

Fertilizers.

Six acres had an application of eight tons of manure the spring of 1904 and four acres had nine tons applied to each in November, 1904, and plowed under the next spring. The six acres which had no manure for this season's crop received 150 pounds of Peruvian guano and twenty-two and one-half pounds of nitrate of potash (saltpetre) per acre, while that manured received 100 pounds of Peruvian guano and fifteen pounds of nitrate of potash per acre.

Yield and Cost of Crop.

Six acres were cut June 24th. It was kept well stirred with a tedder and put into cocks the second day after cutting. The fourth day the hay was aired and carted to the barn in almost perfect con-

dition, without any rain having touched it. The yield was 2.27 tons per acre. The remaining four acres were similarly harvested, yielding 1.98 tons per acre. The average for the ten acres was 2.15 tons per acre.

The cost of seed, labor and fertilizers is given in Table IX. The crop was charged with one-half the manure applied to four acres this season and one-third of the manure on six acres applied for the previous crop.

TABLE IX.

Yield and Cost Per Acre of Oats and Peas.

	Yield per acre.	COST PER ACRE.				Cost per ton of hay.
		Seed.	Labor.	Fertilizer.	Total.	
	tons.					
Six acres	2.27	$2 90	$6 95	$6 09	$15 91	$6 89
Four acres	1.98	2 90	6 95	8 81	18 66	9 42
Average per acre for ten acres	2.15	2 90	6 95	7 18	17 02	7 91

Remarks.

The advantage of raising oats and peas for hay is twofold, namely: (1) When sod has been broken up and there is a shortage of grass land for hay, this crop can be raised, whereas, in order to seed down to grass it would have to be done the August previous, which would interfere with the crop then growing; (2) where it is desired to lay down a field in grass, a crop of peas and oats for hay can be grown and harvested, then seeded to grass. The land has produced one crop and does not have to lie idle in order to get it into grass.

While oats and peas are a little slow in curing, with care and judgment there is very little trouble in harvesting it in good condition. Better quality of hay will be secured by letting one-half of the drying be done in the cock. Oats and pea hay is rich in protein, and when well cured is very palatable to cattle.

Oat and Pea Hay, 1905. Yield, 2.25 Tons per Acre.

VARIETY TEST OF CORN FOR THE SILO.

Four varieties of corn were grown for the silo, which was made a subject of experiment in respect to yield, cost of raising and quality of fodder. The acreage and kinds grown for comparison were:

3 acres Thoroughbred White Flint.
3 " Western Leaming.
3 " Southern or Virginia White.
1 acre Red Cob Ensilage.

Field Notes.

Thoroughbred White Flint.—A variety which has been grown for several years on the College Farm. Its stooling character—that is, its ability to produce several suckers from one stalk; the large number of long, mature ears, often two on a stalk; comparatively large yield and large proportion of nutrients—makes this corn even as valuable for the silo as for soiling.

The crop this season was below the average, because its growth was checked by dry weather and did not attain its usual height and yield of forage.

Western Leaming.—This variety was recommended as being especially vigorous and bred with special reference to its large growth of fodder and yield of forage. The seed came from Iowa. Comparing it with our own Improved Leaming, no great advantage was found in the Western variety. The fodder seemed no more vigorous or the yield greater. There seemed to be a large proportion of large, hard ears, which matured early.

Red Cob Ensilage.—The seed of this variety came from Iowa. It was represented as being a very tall, vigorous kind, heavy yielder and adapted for the silo. The corn happened to be planted quite thick, which may partially account for the lightness of yield. The ears were not well matured.

Southern or Virginia White.—Several years' experience justifies the statement that this corn outranks all others in yield, quality of fodder and vigorous character. The yield this season was below the average, but compares favorably with other varieties. Table X. gives the comparison of results of the four varieties.

TABLE X.

Comparison of Results.

KIND.	COST PER ACRE. Seed.	Labor.	Fertilizer.	Total.	Cost per ton of forage.	Yield per acre.
						tons.
Thoroughbred White Flint	$0 60	$7 55	$2 47	$10 62	$1 19	8.9
Iowa Leaming	45	7 62	2 47	10 54	1 18	9.3
Red Cob Ensilage	50	7 15	2 07	9 72	1 10	8.8
Southern White	48	7 45	3 10	11 08	1 13	9.7
Average	$0 51	$7 44	$2 53	$10 48	$1 14	9.2

Soiling Crops versus Silage.

Efforts have been made to obtain silage enough to allow the comparison of summer soiling crops and silage. A feeding experiment was conducted for two weeks, but the period was so short that the results would not be reliable. However, a comparison of the cost of production of both will be interesting.

A system of rotation of soiling crops had been conducted here since 1896, supplying the roughage to a herd of from forty to fifty head. The data obtained as to cost of growing each crop and the average cost per ton of forage each year are quite uniform, hence the average cost per ton of forage for the present season will be the basis of calculation. The cost of silage will include the cost of growing, cutting and filling of the silo. To the cost of growing the soiling crops must be added the expense of cutting and drawing to the feeding yard, to make comparison on an equivalent basis. Table XI. gives the comparison of results of the two systems.

TABLE XI.

Comparison of Yield and Cost.

	Average yield per acre.	COST PER ACRE. Seed.	Labor.	Fertilizer.	Total.	Cost per ton, cutting and filling silo.	Cost per ton, cutting and drawing soiling crops.	Average total cost per ton.
	tons.							
Soiling Crops	5.4	$1 81	$3 47	$5 12	$10 40	....	$0 72	$2 65
Corn Silage	8.8	47	7 30	3 69	11 46	$1 17	....	2 47

The cost of corn silage this season, namely, $2.47 per ton, is low, notwithstanding that the yield per acre was also low. Barnyard manure was applied to but four out of twenty-four acres, which kept the cost of manures and fertilizers down and offset the low yield. The cost of fertilizers and seed was much higher in production of soiling crops, but this increased cost was offset by the increased cost of labor in growing corn, so that the total cost per acre for corn is only six cents more than for soiling crops. Corn silage cost, per ton, 18 cents more than soiling crops.

The comparison shows that either system can be used with economy, and suggests that the combination of both would give the stock a greater variety and be advantageous in respect to labor.

Nitrating Experiment.

Nitrate of soda was applied as a top-dressing on two fields of rye and one field of wheat and vetch. Each field contained exactly two acres, and the plan of experiment was to apply 100 pounds per acre on a half of each. The nitrate was applied April 15th, after the rye and wheat had got well started. This should be done when the crop is free from dew or rain, as in that condition the nitrate will burn the leaves. Table XII. gives the comparison of yield from all plots.

TABLE XII.

	Acres.	Date of applying nitrate to one-half plot.	Cost of nitrate.	YIELD.		GAIN FROM NITRATE.		Value of nitrate, with forage $3 per ton.
				Nitrated plot.	Unnitrated plot.	Tons.	%	
				tons.	tons.			
Rye	2	April 15.	$2 50	4.78	3.20	1.58	33.0	94.80
Rye	2	"	2 50	6.45	4.80	1.65	25.6	99.00
Wheat and Vetch	2	"	2 50	7.10	6.92	.18	2.5	10.80

The results show that with rye it is a profitable investment to apply nitrate of soda as a top-dressing; that a leguminous crop, such as vetch, is not benefited by such application, and that the top-dressing on wheat and vetch was a loss of $1.96. Nitrate of soda should be applied only on cereals and grasses where it is desired to stimulate the growth very early in the spring. Nitrate applied to crops in summer will seldom be found economical.

III. Experiments with the Dairy Herd.

Influence of Pure-Bred Sire on Common Stock.

It has been found by experience that certain fundamental principles underlie the art of breeding, and must be recognized by everyone whose aim is in the improvement of the herd.

First. The law of heredity, by which we recognize the tendency of the offspring to be like their parents, or descendants like their ancestors, and give rise to the saying, "Like begets like." The external appearance, disposition, tendency to disease, persistency in milking, quality and quantity of milk produced—all these characteristics are given to a greater or less degree by both parents, according to prepotency—that is, the superior influence of one parent over the other in transmitting their peculiarities to their offspring.

Second. The law of variation. No two animals are exactly alike, and the tendency to vary may be transmitted to the offspring. If it were not for this law we would get no improvement. By breeding animals with desirable characteristics and eliminating those animals

undesirable, we can raise the standard of the herd. The law of variation and the law of inheritance work together. The causes of variation are often obscure; it may depend upon changes of condition of climate, food or environment of any sort. It is often important to the breeder to develop some new and valuable quality, as, for example, in the Jerseys and Guernseys by development to an abnormal condition the production of milk rich in fats, the Holstein in the developing of a large amount of cheese-making products in the milk; and the Hereford was driven to a high stage of beef production under special treatment. Variation is not always toward improvement. It is often retrograde, and it is only by close watchfulness that man can keep keep up many improved varieties of animals and plants.

Third. Law of selection. There are vastly more animals produced than is needed for breeding, and only those, therefore, which have the highest aggregate of good points should be bred. With wild animals, those that are the strongest are usually the ones which have the most numerous progeny. With domestic animals, vigor is often secondary to other desirable qualities, and the cows producing the greatest amount of milk usually remain in the herd. Other things being equal, the individual which has descended from one line of ancestry is the most prepotent. In mating two animals, the offspring may—*first,* show equally the qualities of both parents; *second,* the resemblance may be slight, or so strong that the influence of the other parent is scarcely seen; *third,* it may show resemblance to some ancestor whose characters have been entirely lost. The second consideration more often occurs, and the quality of prepotency may be used to advantage to the breeder. A pure-bred animal is usually prepotent, and therefore an inferior animal is a disadvantage.

The male, in stock-breeding, may be considered half of the herd. A female is limited in production to but one animal a season, and half of these will be bulls. If then, the bulls being one-half and their productive capacity fifty-fold, it is obvious that a herd may be improved far more rapidly by superior males than by superior females, and, being more inbred, the male will stamp his characteristics to a greater extent than would be the case if the females of the herd were more inbred. Furthermore, it is recognized that the male more often transmits his quality to the female offspring, while the male offspring takes after the dam. The offspring of a pure-bred sire and a mixed lot of females may show the good qualities of the sire, but if used on the offspring may show the poor qualities of their dams.

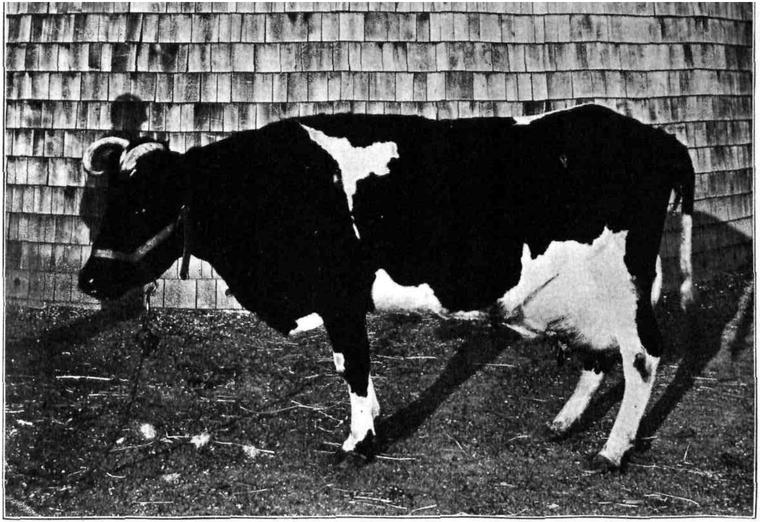
Environment of animals—that is, food, care and climate—is also a great factor in the improvement of the herd. We see the value of abundance of food in the case of wild animals. Where they become separated, so that one-half gets more and better food, we see at once a marked increase in size. Where domestic animals have been kept for some time on insufficient food, if their environment changes so that the food supplied is very liberal, there is a marked change in increase of yield and quality of milk. The wild cow secretes only milk enough for the calf until the calf is able to support itself. We have taught the cow to give a much larger amount and for a much longer period, and this capacity to give milk is transmitted to the offspring. The effect of climate is shown by the high degree of excellence attained by the Channel Island breeds. The climate of the islands of Jersey and Guernsey is tempered by the influence of the Gulf Stream.

Experiment in Breeding.

Since 1898 an experiment has been in progress to study the influence of a pure-bred sire upon common stock. While the data is not entirely complete, it is sufficient to indicate the importance of the work.

The object was to learn the influence a Guernsey sire would have in improving the characteristics of the offspring of some of the best cows of the herd, particularly in reference to the quality of milk from the standpoint of fat content and high color.

Queen was purchased in November, 1897. She was about seven years old at that time. As far as known, her breeding is as follows: Her grandam, a pure-bred Holstein, was bred to a Shorthorn bull, and the daughter bred back to a Holstein. Whether the two sires were pure-bred is not definitely known, but Queen must be at least half Holstein. She has been bred to a registered Guernsey each time since, and of the seven calves which she has dropped, six have been heifers. Her best record was made in 1898, when she produced, in twelve months, 12,486.5 pounds of milk and 500.13 pounds of fat, equivalent to 583.68 pounds of butter. The average per cent. of fat in her milk for that period was 4.01 and her best daily yield is fifty-nine pounds. In fourteen days she has produced 777.3 pounds of milk and 27.2 pounds of fat, which is equivalent to 31.7 pounds of butter. The maximum percentage of fat for any lactation period was 4.17, minimum 3.89, an average of 4.03.



Queen—Yearly Record, 12,486.5 pounds of Milk; 583.68 pounds of Butter.

Table I. gives her record in months for six lactation periods. The seventh period, with a production of 8,485 pounds of milk and 327.67 pounds of fat, is not included in the tables.

TABLE I.

Queen.

LACTATION PERIOD I.			LACTATION PERIOD II.			LACTATION PERIOD III.		
1897.	Milk.	Fat.	1898.	Milk.	Fat.	1900.	Milk.	Fat.
November	876.0	35.04	December	1,074.2	37.60	February	284.4	10.80
December	1,209.8	45.97	1899.			March	1,572.0	56.59
1898.			January	1,582.5	63.30	April	1,324.3	47.67
January	1,107.8	39.88	February	1,242.3	45.97	May	1,314.9	51.38
February	978.3	40.11	March	1,816.0	50.01	June	1,115.5	42.39
March	1,041.0	44.76	April	1,145.0	48.09	July	886.2	34.56
April	886.7	40.79	May	1,123.9	44.96	August	792.0	32.47
May	1,007.7	41.32	June	1,058.8	40.23	September	770.9	31.61
June	979.6	39.18	July	961.2	37.49	October	637.6	27.32
July	718.1	29.76	August	851.9	34.93	November	394.4	18.54
August	521.2	25.02	September	782.1	35.19	December	55.6	2.61
September	442.3	22.11	October	613.1	26.36	Total	9,147.8	355.94
October	367.4	18.37	November	606.2	29.70	Ave per cent. fat		3.89
November	31.7	1.68	December	166.0	8.30			
Total	10,167.6	423.99	Total	12,528.2	502.13			
Ave. per cent. fat		4.17	Ave per cent fat		4.01			

LACTATION PERIOD IV.			LACTATION PERIOD V.			LACTATION PERIOD VI.		
1901.	Milk.	Fat.	1902.	Milk.	Fat.	1903.	Milk.	Fat.
March	1,152.7	42.65	March	1,178.4	45.96	March	152.7	6.11
April	1,422.8	58.33	April	972.1	37.91	April	1,060.4	32.87
May	1,419.6	63.88	May	980.2	35.29	May	1,181.6	43.00
June	1,207.2	48.46	June	948.2	33.01	June	1,009.0	37.33
July	818.1	33.84	July	740.3	32.57	July	884.2	31.70
August	680.8	25.19	August	692.2	29.07	August	799.5	31.18
September	671.0	28.18	September	690.4	31.76	September	731.9	31.47
October	712.2	30.62	October	628.0	28.66	October	697.7	32.09
November	455.6	18.22	November	392.3	19.22	November	628.5	27.85
December	278.2	12.24	December	88.6	4.25	December	578.6	27.77
1902.			Total	7,300.7	297.70	1904.		
January	18.2	0.80	Ave. per cent fat		4.08	January	404.0	19.39
Total	8,881.4	356.91				February	115.2	5.07
Ave. per cent. fat		4.04				Total	8,143.3	325.63
						Ave per cent. fat		4.00

TABLE II.

Queen's Ideal.

LACTATION PERIOD I.			LACTATION PERIOD II.			LACTATION PERIOD III.		
1900.	Milk.	Fat.	1901.	Milk.	Fat.	1902.	Milk.	Fat.
November	750.7	33.78	December.........	854.9	36.76	December.........	1,011.3	44.50
December	925.8	37.94	1902.			1903.		
1901.			January	875.7	34.15	January.........	909.9	37.31
January.........	858.1	36.68	February	674.9	27.67	February	865.0	32.87
February.........	763.8	33.28	March	747.2	32.88	March	834.4	24.21
March	827.6	34.76	April	683.7	28.72	April	714.3	31.43
April	713.2	30.67	May.........	716.2	32.23	May	904.3	37.98
May	697.0	34.15	June.........	663.7	27.21	June	887.1	36.37
June	695.8	32.70	July	543.8	25.01	July.........	651.6	28.67
July	493.5	23.43	August	467.7	22.45	August	522.2	24.02
August	412.0	19.78	September.........	377.1	23.38	September	219.8	12.97
September	332.9	19.97	October.........	62.8	4.71	Total	7,519.9	310.33
October.........	176.7	10.60	Total	6,667.7	295.17	Ave. per cent. fat	....	4.13
Total	7,646.6	347.74	Ave. per cent. fat	....	4.43			
Ave. per cent fat	....	4.55						

LACTATION PERIOD IV.			LACTATION PERIOD V.		
1903.	Milk.	Fat.	1904.	Milk.	Fat.
November	650.0	27.95	November	643.5	28.31
December.........	1,181.4	47.52	December.........	1,354.1	58.23
1904.			1905.		
January.........	1,037.2	44.60	January.........	1,082.1	45.45
February	905.2	38.92	February.........	822.0	34.50
March.........	873.1	35.80	March.........	822.0	32.88
April	881.4	37.00	April	822.6	36.19
May.........	955.8	41.10	May	939.0	38.50
June	943.9	37.76	June	881.6	37.42
July	729.9	32.12	July	698.1	31.41
August	564.5	28.79	August.........	597.6	29.28
September.........	424.0	24.17	September	242.8	14.33
October	90.2	5.95	Total	8,855.4	386.50
Total	9,186.6	401.68	Ave. per cent. fat.........	....	4.37
Ave. per cent. fat.........	....	4.37			

TABLE III.

Queen's Beauty.

LACTATION PERIOD I.			LACTATION PERIOD II.		
1902.	Milk.	Fat.	1903.	Milk.	Fat.
February	688.6	35.18	February	762.8	32.80
March	708.5	34.72	March	960.1	44.16
April	563.6	27.62	April	720.5	38.91
May	561.2	25.82	May	703.5	30.95
June	538.4	24.23	June	648.7	29.84
July	387.8	17.45	July	526.6	25.80
August	348.6	14.64	August	514.5	28.15
September	335.2	18.44	September	420.1	23.75
October	252.8	13.15	October	388.6	21.37
November	204.7	13.51	November	360.3	20.90
December	55.2	3.26	December	327.9	17.38
Total	4,591.6	228.02	1904.		
Average per cent. fat		*4.96*	January	119.9	7.67
			Total	6,453.5	316.68
			Average per cent. fat		4.91

LACTATION PERIOD III.			LACTATION PERIOD IV.		
1904.	Milk.	Fat	1905.	Milk.	Fat.
March	560.5	25.22	February	290.0	17.11
April	1,085.6	47.64	March	1,005.2	45.28
May	1,001.6	43.07	April	947.1	44.51
June	855.8	37.66	May	862.5	41.43
July	718.2	31.60	June	443.1	22.16
August	593.4	28.48	Total	3,547.9	170.41
September	520.9	27.19	Average per cent. fat		4.80
October	497.0	25.84	Cow died.		
November	417.3	22.53			
December	343.3	19.22			
1905.					
January	24.5	1.35			
Total	6,568.1	309.70			
Average per cent. fat		4.72			

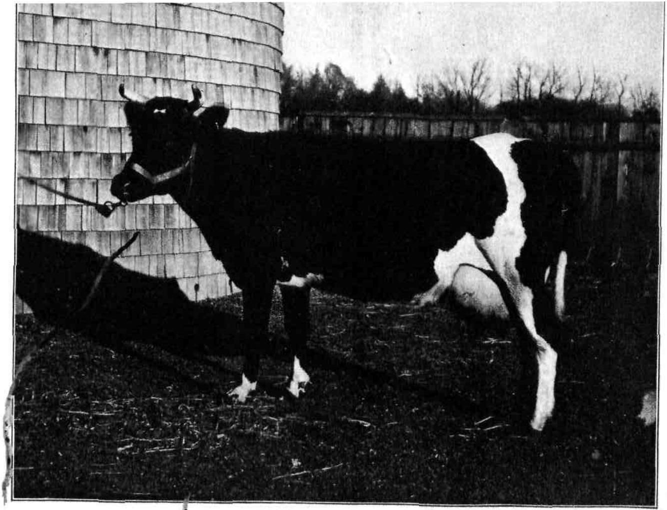
TABLE IV.

Queen's Delight.

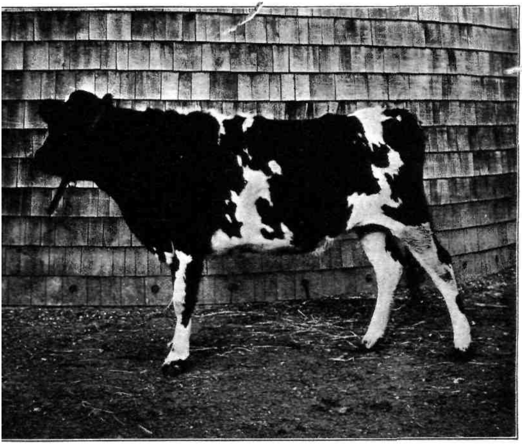
LACTATION PERIOD I.		
1903.	Milk.	Fat.
October	194.7	8.76
November	731.6	35.39
December	725.1	35.53
1904.		
January	677.7	34.56
February	586.1	28.72
March	673.9	34.37
April	670.7	33.54
May	670.4	31.51
June	464.4	30.65
July	437.0	21.41
August	407.7	21.18
September	465.1	24.19
October	479.4	26.85
November	482.5	27.50
December	491.2	28.98
1905.		
January	402.6	23.35
February	341.4	21.17
March	405.6	23.93
April	423.6	21.60
May	224.3	12.79
Total	9,955.0	525.98
Average per cent. fat		5.28

Queen's 5th.

LACTATION PERIOD I.		
19[illegible].	Milk.	Fat.
February	635.5	27.33
March	742.9	29.72
April	718.2	35.91
May	691.2	27.65
June	624.9	26.87
July	592.0	24.86
August	586.5	28.74
September	519.7	24.95
October	527.5	23.21
Total	5,638.4	249.2[illegible]
Average per cent. fat		4.42



Queen's Ideal—Yearly Record, 9,313.4 pounds of Milk; 474 pounds of Butter.



Queen's Ideal 2d.

Queen's Daughters.

Queen's Ideal was dropped at the time when Queen made her best record. She has given birth to three bulls and two heifers, but only one of her daughters was raised. This daughter, Queen's Ideal 2d, has been bred, also, to a Guernsey sire. Queen's Ideal resembles Queen in color and shape of udder, but her general contour is more of the Guernsey type. She has strong dairy points. Her maximum record, thus far, was made in her fourth lactation period, producing 9,186.6 pounds of milk and 401.6[illegible] pounds of fat. Her best yearly record was from April, 1904, to April, 1905, namely, 9,313.4 pounds of milk and 406.26 pounds of fat. The average percentage of fat in her milk for five years was 4.34.

Queen's Beauty.—Unfortunately the record of Beauty is incomplete, as she died suddenly of heart trouble during her fourth lactation period. The first three lactation periods show very strongly the influence of the Guernsey sire in the increased richness of the milk, and the average per cent. of fat for the three complete periods was 4.84, or 0.80 per cent. greater than the average per cent. of fat in Queen's milk. In regard to her maximum record, Periods I. and II. are very nearly alike—one having a little more fat, the other a little milk. The average of the two periods is 6,510.8 pounds of milk and 313.19 pounds of fat. In color she resembled the sire.

Queen's Delight.—Table IV. shows but one long lactation period. This was due to abortion and afterwards failure to breed, for which reason she was sold. Her record shows, however, strong Guernsey qualities. Her milk was richer than any of her sisters, maintaining an average of 5.28 per cent., or 1.24 per cent. higher than her mother's average. She was almost entirely black, but resembled Ideal in form. Her yield of 6,704 pounds of milk for the first twelve months shows that she inherited the milk-producing qualities of Queen.

Queen's Fifth.—In color and form Queen's fifth also closely resembles the Guernsey type. She has made, thus far, but a nine months' record, namely, 5,638.4 pounds of milk and 249.24 pounds of fat. This record for a two-year-old shows exceptional quality. It is fully up to the requirements for admission to the advanced registry of the Guernsey Cattle Club.

TABLE V.

Summary of Results.

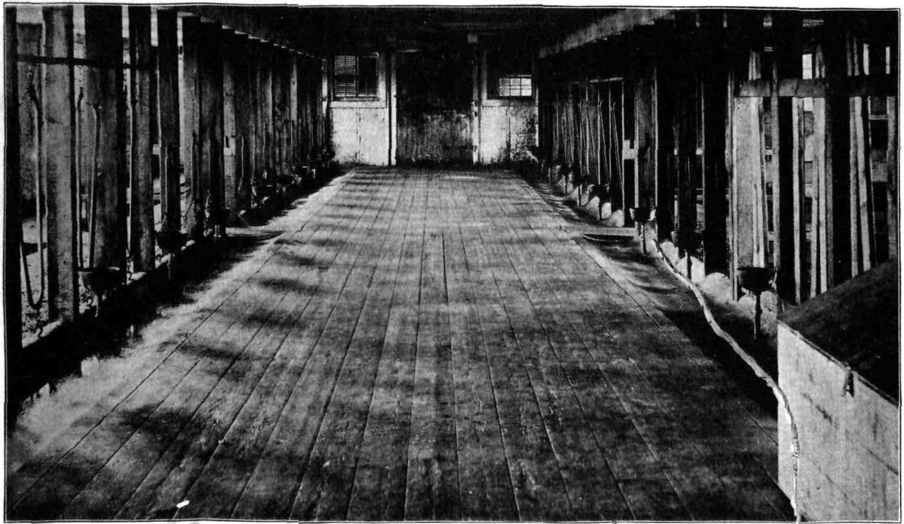
QUEEN.			QUEEN'S DAUGHTERS. QUEEN'S IDEAL.			QUEEN'S DAUGHTERS. QUEEN'S BEAUTY.		
Lactation.	Milk.	Fat.	Lactation.	Milk.	Fat.	L ctation.	Milk.	Fat.
	lbs.	lbs.		lbs.	lbs.		lbs.	lbs
I.—13 mo	10,167.6	423.99	I.—12 m[illegible]	7,646.6	347.74	I.—11 mo	4,594.6	228.02
II.—13 mo	12,523.2	502.13	II.—[illegible] mo	6,667.7	295.17	II.—12 mo	6,453.5	316.68
III.—11 mo	9,147.8	355.94	III.—10 mo	7,519.9	310.33	III.—11 mo	6,568.1	309.70
IV.—11 mo	8,831.4	356.91	IV.—12 mo	9,186.6	401.68	IV.— 5 mo.....	3,547.9	170.41
V.—10 mo	7,300.7	297.70	V.—11 mo	8,855.4	386.50	Maximum.....	6,453.5	[illegible]
VI.—12 mo	8,143.8	325.63	Maximum.....	9,186.6	401.68	Ave. per cent. fat	....	4.84
Maximum.........	12,523.2	502.13	Ave. per cent. fat	....	4.34	Incomplete—cow died.		
Ave. per cent. fat.	....	4.03						

QUEEN'S DAUGHTERS.

QUEEN'S DELIGHT.			QUEEN'S 5TH.		
Lactation.	Milk.	Fat.	Lactation.	Milk.	Fat.
	lbs.	lbs.		lbs.	lbs.
I.—12 mo	6,704.4	339.81	I.—9 mo..................................	5,638.4	249.24
16 mo..................................	9,955.0	525.98	Average per cent. fat.......	....	4.42
Average per cent. fat, 12 mo..	....	5.07			
Average per cent fat, 16 mo..	....	5.28			

Results.

In comparing the results as given in the summary (Table V.), we notice that the records are remarkably high for heifers, approaching their dam in this particular characteristic, yet in every case the content of fat was very much higher. This, in view of the fact that *the period of lactation with the heifers was included in twelve months*, while two periods of Queen's record covered thirteen months, indicate the great value of the Guernsey in transmitting its characteristics to animals of uncertain breeding.



Concrete Mangers in Dairy Barn.

Furthermore, these results suggest the advisability of Guernsey sires not only in those districts where butter is the chief object, but also where milk is produced for a high-class retail trade. The results in the improvement of the offspring of these animals are strikingly shown in the increased fat content of milk and in the higher color. In other words, the effect of Guernsey blood has been to improve the animal both for milk production and for butter. Such breeding cannot help but raise the standard of retail milk, and thus encourage the use of a higher grade article, which from a nutrition standpoint is richer in fat and total solids than the average product.

CONCRETE MANGERS FOR CATTLE.

In a previous report* the building of a new cattle wing is fully described, giving description of concrete floors and mangers. The old stable, eighty feet long, having two rows of stalls, needed attention, and the old wooden mangers were replaced by more sanitary concrete ones.

The wood mangers were two feet wide and three inches deep, with a partition separation between cows. There was always considerable dripping and wasting, as the cows drank from the cups, so that the wood was continually wet and had become decayed and unfit for cattle to use. Furthermore, the water had so far penetrated the timbers that the sills and posts had to be replaced. To protect the new timbers and floors, the manger bottom was lowered to allow for three inches concrete, made from one part of Portland cement to three parts of sharp sand and five parts of coarse gravel, and a one-inch top-coat of one part of cement to two parts of sand. The cement was brought up over the entire main-sill, to allow no moisture to penetrate to the timbers.

The new manger is twenty-four inches wide, the bottom three inches below the feeding floor and one and one-half inches below the planking on which the cattle stand. The cement above the sill is six inches above the plank platform, which protects the timbers and prevents the feed from getting into the bedding. Bolts were anchored in the cement to provide attachment to stanchions.

The expense can be reduced to cost of materials where the labor is performed by intelligent farm help. The cost of labor for con-

* See Exp. Station Report for 1901, p. 286.

creting mangers was about seventy-five cents per running foot. The carpenter work in our case was much more, since new timbers and posts had to be replaced.

Sanitary Milk Room in Barn

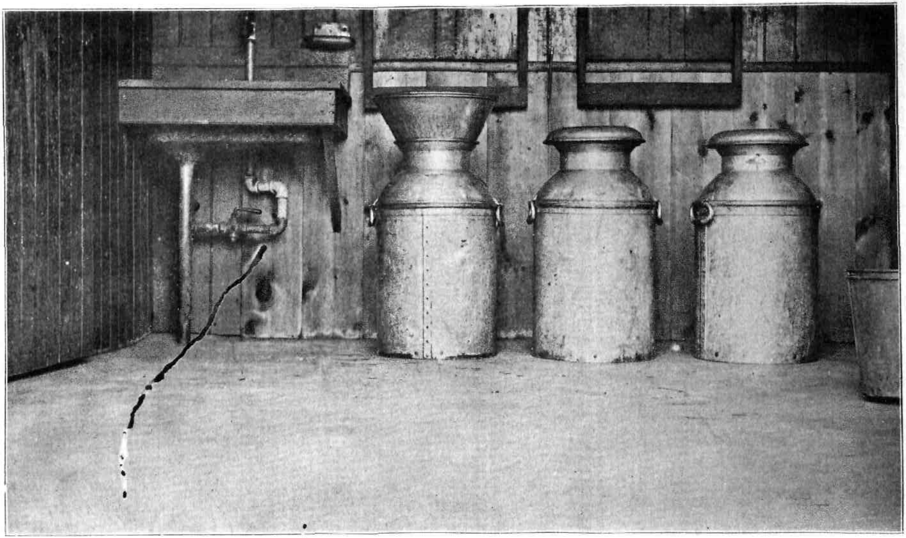
Where milk must stand for any length of time it is quite necessary to have some place convenient to and yet outside of the stable, where the milk is strained and where records can be kept. If such a room has wood floors, in a short time they will absorb undesirable odors—in fact, soon the room will be in a condition as objectionable as the stable.

Since the last report our milk-room has been repaired; a concrete floor has been laid and open plumbing put in, so that there is no chance for foul matter to collect or wood to decay, except along the bottom of the partitions; even here this is reduced to a minimum. The floor has four inches of concrete, including a top-coat of cement. The drainage is slightly towards the center, where a two-inch pipe connects with the sewer. Such a room can be made with farm labor and is practical from economic and sanitary standpoints.

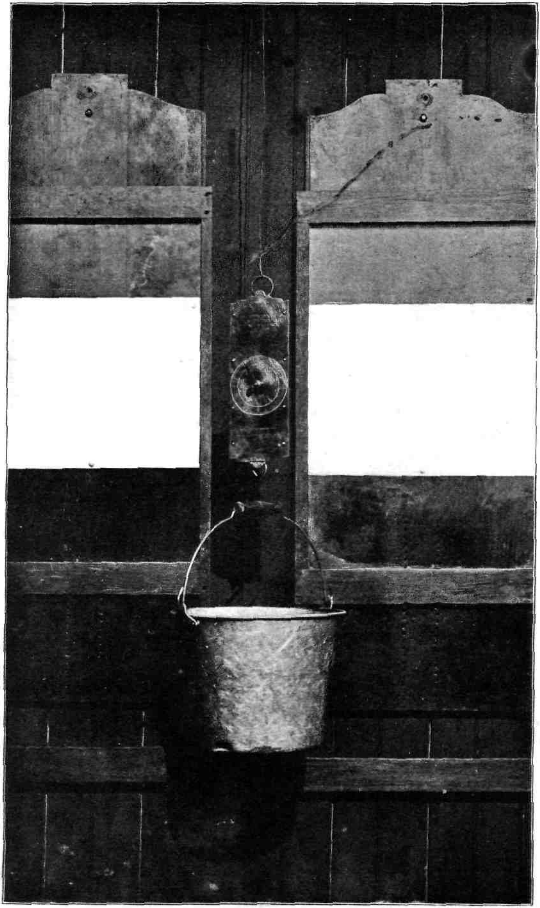
WHAT THE MILK SCALES AND BABCOCK TEST INDICATE.

The weighing of the milk and the keeping of daily records is considered by a great many farmers as a waste of time, and therefore unnecessary. This idea is a costly error to the farmer, for there are probably but very few herds in this State but that have one or more cows which are bringing in not one dollar's worth of profit to their owners. It is true that most dairymen can estimate the cost of food and labor and know whether they are making or losing money, but whether a certain cow is being kept at a profit or loss cannot be definitely determined, except from actual records of her production.

The milk scales, record sheet and Babcock test should be included in every dairyman's equipment, by the results of which he can cull out the unprofitable cows from the herd and determine each month just what his profits are. The lack of knowledge of each cow leads to needless losses. There are probably in every herd, where no records are kept, cows which could be sold for beef, and have a herd that would pay a greater profit on the food consumed.



Milk Room in Dairy Barn.



Methods of Obtaining and Keeping Records.

There are chances of error in estimating the value of a cow: *First,* in the length of lactation period. A cow giving but twenty pounds of milk daily, when fresh, would be considered very ordinary, yet if she continues this yield for 300 days, or a total of 6,000 pounds per year, she shows a good record. On the other hand, a cow yielding forty pounds of milk daily, when fresh, but very soon rapidly shrinking, would lead the owner to think, unless he took this into consideration, that he had an exceptionally good animal. *Second,* a dairyman may think that because he has a strong strain of Jersey or Guernsey blood in his herd they are of necessity profitable animals. On the contrary, there are many worthless animals in every breed, which are not as profitable as an ordinary grade or scrub. *Third,* many estimate the richness of the milk by its appearance. Within certain limits this may be true, yet often the color is due to the color of the butter-fat. There are records of Guernseys producing milk with less than 4 per cent. fat, yet which had a high color. *Fourth,* a cow giving 6,000 pounds of 3 per cent. milk would be no more profitable than one producing 3,000 pounds of 6 per cent. milk. Neither cows would be profitable animals, but the 6,000 pounds' cow might be considered much the most valuable.

RECORDS OF THE COLLEGE FARM HERD.

Since 1896 daily records of the weights of milk of each cow in the herd have been made and records preserved, together with a semi-monthly and a portion of the time weekly Babcock fat test of each. The records of those cows remaining in the herd for the entire year have been published in each yearly report since, with the average cost of food of each cow. These nine-year records, therefore, furnish abundant data of the cost of producing and handling milk. They show that cows producing 5,000 pounds of 4 per cent. milk and 200 pounds of fat are profitable animals, but mature cows producing less than this amount should be disposed of. This method of culling out unprofitable animals, determined thus by the milk scale and fat test, is the only way to build up the standard of the herd.

TABLE VI.
Individual Records Showing Gain or Loss.

NAME OF ANIMAL.	MAXIMUM YIELD PER YEAR. Milk.	MAXIMUM YIELD PER YEAR. Butter.	MINIMUM YIELD PER YEAR. Milk.	MINIMUM YIELD PER YEAR. Butter.	YEARLY INCOME FROM MILK AT 8C. PER QUART. Max. Yield.	YEARLY INCOME FROM MILK AT 8C. PER QUART. Min. Yield.	YEARLY INCOME FROM BUTTER AT 20C. PER POUND Max. Yield.	YEARLY INCOME FROM BUTTER AT 20C. PER POUND Min. Yield.	AVERAGE NET RETURN FROM LABOR, DEDUCTING COST OF FEED. Milk.	AVERAGE NET RETURN FROM LABOR, DEDUCTING COST OF FEED. Butter.
	lbs.	lbs.	lbs.	lbs.						
Queen	12,486.5	583.48	6,275.0	299.85	$174 81	$87 85	$116 69	$59 97	$81 38	$38 38
Queen's Ideal	9,313.4	473.97	6,678.8	358.22	180 39	98 50	94 79	70 64	68 94	34 71
Queen's Beauty	7,802.8	403.06	4,594.6	228.02	102 24	64 82	80 61	45 60	36 62	16 44
Queen's Delight	6,704.4	396.44	......	......	85 40	......	79 29	......	38 90	32 79
Queen's 5th *	5,638.4	290.78	......	......	73 94	......	58 16	......	43 91	28 16
Helda	10,946.4	489.85	7,172.4	315.29	150 24	100 41	97 97	63 06	76 83	30 61
Cherry	5,958.6	306.59	5,084.4	268.06	88 85	70 46	61 32	52 61	33 91	8 96
Colantha	9,593.4	368.96	8,731.8	319.10	184 27	121 24	73 79	63 82	78 75	19 30
Mijuke	9,214.2	374.24	7,618.1	308.82	128 99	106 58	74 85	60 76	69 79	19 81
Pearl	8,720.9	430.76	6,289.4	306.52	122 69	88 04	86 15	61 30	57 07	25 78
Model	8,351.7	407.05	6,685.1	321.60	116 92	98 59	81 41	64 32	60 26	26 87
Model's Prospect	4,725.0	391.12	4,876.1	275.61	66 15	61 17	78 22	55 12	17 66	20 67
Model's Perfection	5,278.6	271.64	3,482.4	183.25	73 88	48 75	54 31	36 65	16 29	—0 52
Sebolt	8,140.2	439.80	6,226.2	293.80	113 96	78 17	87 96	58 66	46 91	26 65
Sebolt's Daisy	7,861.5	444.19	5,164.5	321.65	110 06	72 30	88 84	64 33	45 18	30 59
Sebolt's Belle	4,218.5	257.54	3,131.8	163.17	59 05	43 85	51 51	32.63	5 45	—3 91
Select	7,621.7	386.97	5,155.2	286.51	106 70	72 17	77 19	47 30	40 44	18 21
Gypsey	7,874.8	401.74	6,149.6	301.45	110 14	86 29	80 35	60 29	50 22	22 32
Diana	7,059.0	390.04	4,519.3	257.24	98 82	63 27	78 00	51 45	34 88	20 06
Victoria	9,958.5	419.56	5,859.3	215.69	139 35	82 08	83 91	43 14	61 69	14 52
Yolande	4,426.9	233.56	3,781.0	172.46	61 98	52 93	46 71	34 49	11 46	—5 40
Beula	7,171.0	411.87	3,443.9	176.19	100 89	48 21	82 27	35 24	27 30	11 76

* Nine months' record for a two-year old.

TABLE VI.—Continued.
Individual Records Showing Gain or Loss.

NAME OF ANIMAL.	MAXIMUM YIELD PER YEAR.		MINIMUM YIELD PER YEAR.		YEARLY INCOME FROM MILK AT ?C. PER QUART.		YEARLY INCOME FROM BUTTER AT ?C. PER POUND.		AVERAGE NET RETURN FROM LABOR DEDUCTING COST OF FEED.	
	Milk.	Butter.	Milk.	Butter.	Max. Yield.	Min. Yield.	Max. Yield.	Min. Yield.	Milk.	Butter.
	lbs.	lbs.	lbs.	lbs.						
Zola	8,517.5	385.29	6,818.1	343.88	$119 25	$95 45	$77 06	$68 78	$58 85	$28 92
Raritan	6,287.8	301.62	5,162.4	233.35	88 01	72 27	60 32	46 67	32 14	5 49
Hazel	7,281.6	378.82	3,849.8	221.80	101 94	53 89	75 76	44 36	30 92	18 06
Buttercup	5,774.6	305.40	3,978 6	202.81	80 84	55 70	61 08	40 46	21 27	3 79
Black	5,724.7	252.16	3,694.4	169.46	80 15	51 72	50 41	33 89	17 94	—5 85
Roma	4,522.6	382.88	3,995.2	324.96	63 31	55 93	76 48	46 99	14 62	16 74
Regena	4,762.8	191.77	3,488.2	142.61	66 68	47 83	38 35	28 52	10 36	—18 57
Rose	5,814.8	268.62	5,403.7	247.87	81 41	75 65	53 72	49 57	30 53	3 64
Alta	6,435.3	314.18	5,346.3	271.06	90 09	74 85	62 84	54 21	35 47	11 52
Hospital Heifer	5,962.6	316.25	3,818.5	199.41	83 48	53 46	63 25	39 88	23 47	7 57
Princess	8,303.4	480.90	5,026.7	268.82	116 25	70 37	96 18	53 76	44 81	10 97
Regena 4th	4,901.8	259.30	3,489.7	171.98	68 63	48 86	51 86	34 39	13 49	—2 13
Blue	7,840.1	414.96	6,496.7	341.60	107 96	90 95	82 99	68 32	51 46	27 56
Viola	6,982.7	274.68	6,192.1	307.18	97 75	86 69	54 91	61 43	45 22	11 18
Evesta 5th	4,223.5	201.80	4,010.9	209.01	59 13	56 15	40 36	41 80	10 84	—5 92
Evesta 6th	4,018.4	192.70	....	....	56 26	....	38 54	....	11 26	—6 46
Evesta 7th	4,583.6	228.40	....	....	64 17	....	45 68	....	19 17	68
Myrtle	4,416.6	301.10	....	....	61 83	....	60 22	....	15 17	13 56
Lilith	5,528.0	385.97	5,207.7	340.47	77 32	70 11	77 19	68 01	26 72	26 60
Sebolt 5th	4,084.2	247.28	....	....	57 18	....	49 46	....	11 18	8 46
Woodlawn	9,511.5	452.46	6,586.0	296.60	133 16	92 20	90 49	59 32	65 68	27 91
Genesta	6,042.8	305.95	4,508.8	262.63	84 60	67 25	61 18	52 52	28 93	9 88

Table VI. gives a summary of individual, maximum and minimum yearly yields of milk and butter, the yearly income at three cents per quart for milk and twenty cents per pound for butter, and the net gain after deducting the cost of food, which represents the labor, remuneration and interest. To this might be added the value of manure excreted, which has not been estimated.

Allowing $22 per cow for labor and interest on the value and depreciation of the herd, we find, with milk wholesaled at three cents per quart, a price one-half cent lower than the average received in this vicinity, that thirty cows have paid the owners a profit, besides the manure valuation. Of this number of cows three have netted over $52 per year, a good interest on capital invested; nine between $25 and $50 per year, and sixteen over $5, but under $25 per year. Ten cows did not pay for the food and labor, and from one cow, Sebolt's Belle, $5.45 and the manure was the only remuneration for labor.

With butter at twenty cents per pound, seven cows did not even pay for the food consumed, and with one cow, Regena, this deficit was at least equal to the value of manure excreted, so that there was no remuneration for labor. Only thirteen out of forty-four records tabulated show any profit above the manure, after paying for the feed, labor and interest on capital and depreciation of the herd.

These results ought to show conclusively the value of keeping records. Can a dairyman afford to be without a milk balance and Babcock tester, when a very little outlay of capital will purchase both and give exact information of what each animal is doing? If it is impossible to spend time to daily weigh the milk, let it be done twice a week and the fat test made once a month. Calculation on this basis will not be far in error. Surely the benefits received will far more than repay the trouble.

REPORT OF THE BIOLOGIST.

REPORT OF THE BIOLOGIST.

This report treats of investigations in two different lines, viz.:

I. Egg-Production of Virgin Fowls.
II. Studies in Oyster Propagation.

I. Egg-Production of Virgin Fowls.

In the fall of 1884, while studying the subject of the developmental tendencies present in unfertilized eggs, that develop normally only when fertilized, I wrote my brother, who was then running a farm in Wisconsin, to separate three pullets while still immature, and to raise them apart from association with the male bird, and to keep their eggs so that I could study them during the following summer. Accordingly, when I came "home" the next June, I found three young Barred Plymouth Rock hens shut up in a compartment of a cellar, and the shelves near by were covered with eggs that had been laid.

This sight removed any thoughts that I had as to whether the absence of the male might not cause a certain amount of enfeeblement of the reproductive instincts or activities. Such ideas, to be sure, were not well grounded in the biological evidence offered by the animal kingdom in general, for egg-production or "*ovulation*" is a process that occurs in female organisms entirely precedent to or in preparation for the later history of fertilization and reproduction. Still, it appeared reasonable that the presence of males might, in the case of the higher animals where courtship obtains, be a stimulus to reproductive activities in the opposite sex.

For many years past the writer has raised chickens in a small way, and has weeded out the young males, so that the flock of hens has, for the most part, lacked the presence of the "chanticleer." Occasionally a "rooster" from a neighboring flock has succeeded, against obstacles, temporarily in visiting these hens, and it has seemed to us

that, soon after such visits, the hens that had contentedly laid their eggs almost continuously, began to steal nests and to try assiduously to rear chicks from eggs that failed to hatch. In case we desired to add new members to the flock, such "broody" hens were supplied with eggs whose fertilization was not in doubt. In this way new blood was introduced, although, of course, it could not be cross-bred or amalgamated into the stock.

The unfertilized eggs that had been sat on we invariably found to be entirely fresh, as well as not "addled." An "addled" egg may be "fresh" in the sense that it is undergoing healthy development, but it is, of course, spoiled for food. In this connection it may be observed that every fertilized egg, however "newly laid," contains an embryonic chick in a degree of development depending on the extent of the time to which it has been subjected to warmth subsequent to the time it was laid. Every fertilized egg is fertilized while it consists only of the "yolk" at the time it leaves the ovary or just as it enters the oviduct or egg-tube. In the oviduct it must remain long enough to receive a coating of *albumen* known as the "white" of the egg, and finally the shell is formed around all. Meanwhile the temperature in the interior of the hen is eminently favorable to the development of the fertilized germ, and so when the egg is laid the development has always completed the first stage.

If the egg becomes cold the development is arrested, but it continues again every time the egg is warmed up. If several hens visit the same nest to lay their eggs, the earlier-laid eggs become really "incubated" for a time, just as if they were under a sitting hen. During excessively warm summer weather the development also continues in fresh eggs, *i. e.*, in eggs whose germs still are full of vigor. An old egg, in which the germ may have nearly died, due partly to the fact that the egg is slightly stale, would not develop under such conditions, although decay or deterioration would be hastened. On the other hand, the strictly fresh or new-laid eggs would be more apt to undergo development and to become addled. As only about twenty-four hours of development will bring an egg to the point at which it is spoiled for culinary purposes, it is no wonder that eggs, secured after a hunt around straw stacks, etc., for nests, may be "strictly fresh" and "new laid," and yet lack much in desirability.

With unfertilized eggs there could be no question of addling, and the only change that could ensue would be the far slower one of growing "stale," and ultimately of undergoing decay. It seems likely

that unfertilized eggs may resist decay much longer than fertilized ones.

It appears, then, likely that if eggs are to be produced, not for breeding, but solely for culinary purposes, the following advantages would follow if the male bird was absent from the flock of domestic fowls: (1) less food would be eaten—at any rate, there would be "one less mouth to feed;" (2) hens may not become broody so often nor for so long periods, or may be more easily broken of the instinct, thus absolutely more eggs would be laid by each member of the flock; (3) these eggs would be better keepers, and so the loss due to addling, and perhaps also to deterioration and decay, would be decidedly lessened.

To test these and similar points we inaugurated, in the summer of 1904, at the College Farm, a set of experiments with poultry. While they have been planned by the writer, the work of running the experiments has devolved upon Mr. George A. Billings, the Dairy Husbandman, and are under his supervision. To him must be credited the tables and records of this experiment. The present report is one of progress merely. The experiment has not been fully developed along all the lines indicated above. The main record, so far, relates to the average number of eggs produced.

The experiment was planned and has been carried out as follows: A portion of a shed was divided by a partition into two equal pens. Each pen communicates with a yard surrounded by a high wire-netting fence. In these pens, about May 10th, 1904, a considerable number of chickens were hatched under sitting hens. As soon as the chicks were old enough to allow one to distinguish the sex, the male chicks were "weeded out." By September only female fowls remained.

During the summer these fowls were fed on "chick feed," a commercial mixture of cracked corn, wheat, millet, etc. In general, during the laying season, they received once per day a "mash" of equal parts of bran, corn meal, gluten and a few meat scraps. When green stuff was available, grass, sods, etc., were introduced occasionally. During the winter and up to July the fowls also received twice daily a mixture of corn, wheat and barley, and during the hot season, and when not laying, this ration was given only once per day. They have never been allowed to leave their pens or yards. The pens are about twelve by twelve feet and the yards are twelve by twenty-four feet.

Before the time the laying began the flock of hens was divided as equally as possible between the two pens, six White Plymouth Rock

pullets and four Barred Plymouth Rocks being placed in each, and thenceforth there has been no intercommunication. One of the hens escaped, July 1st, from pen No. 2. She was not allowed to return, it being supposed that the results would be less vitiated by introducing a lower divisor when the average was figured than by the return of a hen that had associated with male birds.

A general attempt was made to keep the nutrition conditions alike for both flocks, but no experiment has as yet been conducted in which the food enters as a factor. The amount fed has been determined in the usual manner for fowls not under experiment, viz., by giving only as much food as would be consumed.

The fowls began laying in December and the comparative record was kept from December 27th on. By January 1st nine eggs had been laid in pen 2 and seven in pen 1. The following tables show the monthly records for each day to the end of October. Unfortunately the sheets for March have been lost, and this is the more deplorable *as it was March 1st that the real test began. At that date a cockerel* was introduced into pen 1, and if this produced an immediate effect we cannot tell. From memory only is left the impression that the hens in pen 2 laid more eggs than in pen 1, but the exact totals for that month are not known.

As seen from the tables, the season has been divided into three periods. During January and February the two flocks were practically as alike as we could make them. Each had ten hens; from each over 200 eggs were produced, viz., 202 in pen 1 and 267 in pen 2, and each flock lacked the presence of a male fowl. This constitutes Period I. March 1st a cockerel was added to flock No. 1, and there was increased egg-production in both pens. But the increase in pen 1, which contained the cockerel, was much greater than in pen 2, when the total egg-production to the end of June is considered. During April, May and June 446 eggs were laid in pen 1 against 377 in pen 2, and so the relative positions of the two flocks during this period were reversed, as compared with the previous periods, though the total number of eggs produced since December was almost exactly the same. In July, and especially in August and September, the egg-production was greatly reduced in both pens, *the number laid until the end of October being 183 in pen 1 and 159* in pen 2. But during this period only nine hens were present in pen 2, so that the average per hen is, respectively, 18.3 eggs for pen 1 and 17.7 eggs for pen 2.

Table Showing the Daily Egg Production in Pen I. from January to October, 1905. Cockerel Introduced March 1st.

DAY OF MONTH.	January.	February.	April.	May.	June.	July.	August.	September.	October.	
1	1	1	6	9	7	2	....	1	2	......
2	....	3	6	3	7	....	....	2	1	......
3	2	4	4	9	7	....	2	1	3	......
4	2	3	7	4	4	....	1	....	3	......
5	3	5	4	5	6	2	1	1	3	......
6	1	4	3	4	6	....	1	....	2	......
7	3	2	5	9	7	1	1	....	4	......
8	2	4	4	5	3	1	1	....	2	......
9	4	3	6	4	5	2	2	....	5	......
10	3	5	6	4	6	2	1	....	4	......
11	3	4	3	5	4	2	2	....	2	......
12	6	4	6	3	4	1	2	....	3	......
13	2	3	6	6	5	1	2	....	4	......
14	4	3	7	2	1	2	....	....	2	......
15	4	5	9	2	5	2	2	....	5	......
16	5	1	5	2	2	1	1	....	3	......
17	3	3	3	2	4	1	....	....	3	......
18	3	5	9	4	5	1	4	....	3	......
19	5	3	5	4	5	1	2	....	2	......
20	6	1	7	4	2	....	3	....	3	......
21	2	5	6	5	3	1	....	1	2	......
22	6	5	8	4	4	3	5	....	4	......
23	2	6	4	4	2	2	1	1	3	......
24	5	4	5	3	4	1	1	....	3	......
25	2	1	10	8	3	2	2	1	4	......
26	5	4	6	2	3	....	....	1	4	......
27	4	4	6	3	4	....	2	1	2	......
28	4	5	3	5	1	1	1	....	3	......
29	3	....	7	9	2	....	1	1	4	......
30	5	....	5	7	2	....	2	1	3	......
31	2	....	....	7	....	....	1	....	4	......
Totals	102	100	176	142	128	32	44	12	95	831
	Period 1.		Period 2.			Period 3.				
Individual averages per period,	20.2		44.6			18.3				
Daily averages	.34		.49			.15—				
Remarks	May 7th, four hens broody. May 17th, six hens broody.					July 6th, six hens broody.				

Table Showing the Daily Egg Production in Pen II. from January to October, 1905. The Male Fowl Absent Completely.

DAY OF MONTH.	January.	February.	April.	May.	June.	July.	August.	September.	October.	
1	3	5	6	3	6	2	......	......	1	......
2	4	4	5	4	9	1	......	......	4	......
3	2	3	7	8	8	2	......	......	2	......
4	5	4	3	7	2	......	......	......	1	......
5	2	1	3	9	7	2	......	......	2	......
6	5	4	7	6	9	2	......	......	3	......
7	2	5	3	5	7	4	1	......	1	......
8	4	4	7	9	5	2	1	......	3	......
9	6	5	4	8	5	4	1	......	1	......
10	2	4	4	4	7	5	......	1	2	......
11	5	3	3	8	6	3	1	......	3	......
12	4	5	2	8	4	5	1	......	2	......
13	5	7	5	7	4	4	1	......	3	......
14	4	6	4	6	4	4	......	......	2	......
15	5	6	2	5	2	3	1	......	2	......
16	4	8	4	6	2	4	1	1	2	......
17	4	3	4	5	3	4	......	......	3	......
18	5	6	3	2	5	......	......	1	1	......
19	3	10	1	4	1	1	1	1	4	......
20	2	7	4	3	4	......	......	......	1	......
21	4	4	2	3	4	1	3	......	2	......
22	5	6	2	2	2	1	......	1	2	......
23	4	7	3	2	3	......	2	2	3	......
24	5	5	3	1	4	......	......	1	3	......
25	3	7	3	1	1	......	1	1	4	......
26	2	4	2	1	2	......	1	2	3	......
27	5	9	2	2	3	......	1	......	4	......
28	4	7	2	2	2	......	......	2	4	......
29	3	......	3	5	2	......	......	......	2	......
30	4	......	4	5	1	......	......	2	1	......
31	3	......	......	5	......	......	......	......	2	......
Totals	118	149	107	146	124	54	17	16	78	808
	Period 1.		Period 2.			Period 3.				
Individual averages per period,	26.7		37.7			17.7				
Daily average	.45		.41 +			.14 +				
Remarks	May 11th, one hen broody. May 17th, six hens broody.					July 1st, and later, only nine hens present. July 6th, one hen broody.				

These tables show that the hens in pen 1 laid 831 eggs besides those laid in March, and that during the same period the hens in pen 2 laid 803 eggs. The ratio approaches nearer to equality when it is considered that there were only nine hens in pen 2 during the latter half of the season. We must, however, note that during the first two months the two pens were on an equality, both as respects the number of hens and the absence of the male. But in this period the hens in pen 2 laid nearly a quarter more eggs than those in pen 1. If the egg-production had been equal in this period the ratio of inequality between the two pens would have been greater for the entire season. But we might take the ratios between the two flocks during the first two months, when, so far as could be determined, everything was alike for the two pens, as indicating the relative inherent reproductive capacities of the two flocks. If this be taken into consideration, the subsequent difference in the record of these flocks becomes of still greater moment. But it is decidedly unfair to take the record of egg-production of a flock at one period as a measure of expectation for later periods, because it frequently happens that there is a reaction from the very excessive fertility of a period, resulting in a diminished production in a later period, and *vice versa*. We might naturally expect that if the egg-production in pen 2 exceeded that of pen 1 in the first period, the ratios might be reversed in Period II. But for this expectation we would be obliged to infer that the introduction of the cockerel into pen 1 was so great a stimulus to egg-production as to nearly double the normal effect of the approaching summer in causing an increase in the egg-production. It will thus be seen that our conclusions from these statistics depend somewhat on the point of view. Certainly, in the third period, the effect of the presence of the male was very slight, if we consider the extra sixteenth of an egg per hen that pen 1 has to its balance sheet against pen 2 as due to such influence.

As the entire season draws to its close, the total production of eggs in the two pens approaches equality. We therefore hesitate to make any dogmatic assertions at this early stage in the experiment. Still, should we plot the curves of egg-production for the two flocks, we would see a decided rise in the curve, coincident with the introduction of the male. This certainly is interesting, and deserves to be tested further.

As regards the effect of presence or absence of the male on the tendency to be "broody," the tables show that the difference in the pens is not of great moment, though there is a real difference so far as the experiment has gone. The total number of broody hens noted in pen 1 has been sixteen, while the number in pen 2 was but half that. Nevertheless, it is to be noted that on May 17th there were six hens broody in each pen.

II. Studies in Oyster Propagation.

In our report for 1904 we announced that these investigations had been pursued in a systematic order, and that the work of directly experimenting with the fixation of the "spat" had just been initiated. That season was, however, so unfavorable in respect to the character of the available spawn that our results, negative as they were, lost much in significance and importance.

By contrast, the season of 1905, concerning which the present report is made, was, on the whole, quite favorable in several respects We began the work early, and prosecuted it continuously throughout the season. The temperature and other weather conditions were usually all that could be desired. We installed apparatus, which fulfilled, so far as could be ascertained, all the essential requirements of the experiments, and finally we extended the work by making comparative studies at several stations along our coast.

It is sometimes claimed that when an oysterman "plants" shells upon the sea bottom and secures an attachment of oyster spat, the resulting "oyster seed" having been secured by the aid of art, is a truly artificial propagation of oysters. Such seed may be termed "artificial seed" in contradistinction to the natural seed secured from "native reefs" or "natural beds."

From the biological standpoint, however, there is no real distinction in the production of seed in these two ways. Whether by natural processes, aside from human aid, a bed of shells or other "cultch" is present in a place where oysters throw out their spawn and "catches a set" of the developing young, or whether in such places (or so adjacent to oysters as to be within range of currents bearing such oyster fry) man introduces cultch, the real production of oyster spat is completely a natural process, and is not only beyond man's present control,

but we lack a full knowledge of the conditions of water currents, temperature, ripeness of spawn, accidents of fertilization, etc., upon which the production of viable spat depends. To such an extent do we lack this knowledge that nobody has ever succeeded in a direct production of oyster seed by proceeding to build a pond filled with suitable water, stocked with cultch, securing proper oyster spawn, fertilizing the eggs in large numbers, raising the fry to the fixation stage and planting them so that they attached to the cultch, and then rearing them until they were vigorous seedlings, suitable for transplanting to a bed where they can grow to marketable size.

When all this is understood and successfully performed again and again, then we can speak of "artificial oyster propagation," and then we shall be enabled to breed oysters, to produce desirable crosses and to evolve new and improved races. Then will be eliminated the present elements of "chance" that obtain in oyster culture. At present the planter can only take what nature gives him. He may help considerably by planting shells, but whether he succeeds in getting seed, or whether he succeeds in finding suitable ground on which to grow his "plants," depends simply on "luck," or on experience that at such or such a location he has previously and generally been successful. The conditions on which such success depends are "secrets" yet to be revealed, or are "guesses" without scientific foundation.

We therefore consider every oyster secured on shells planted in our bays as a "natural spat." This does not mean that the man who planted the shells has no property rights in the results of his labors. Most assuredly, to the planter alone belongs the gift that nature has prepared, because without his efforts there would have been no oyster seed upon that ground. It is only the seed produced at public expense, or at no expense to anyone, that can rightly be public property. We are not here concerned, however, with legal quibbles. We desire simply to give the biological justification for calling all oyster seed at present available *natural* seed.

To those who know how easily oyster eggs may be secured and fertilized, and how rapidly the eggs develop into swimming fry, it seems no great problem to develop a system of artificial oyster propagation. But he who has spent years in trying to get at the secrets of nature that underlie the various aspects of a complete system of artificial oyster propagation realizes that to secure this knowledge requires a vast amount of patience and study. The most discouraging

feature discovered in our investigations has been the fact that after securing the apparently best spawn present in oysters, at the height of the spawning season, and making a careful fertilization experiment, and after seeing a fine lot of beautiful embryos develop, the latter may lack the vigor needed to complete their growth under conditions apparently identical with those under which another lot of spawn has developed satisfactorily. Still worse than this is the fact that the initial vitality of the spawn may differ so much that the eggs may stop growing in different stages of development. The fact that a certain lot of embryos has grown satisfactorily for some time is no guarantee that they will continue to live.

Under such circumstances, when in any given experiment the fry degenerate, it is impossible to say whether the failure to grow is due to a lack of vitality, the result of immaturity or over-maturity, or unfavorable influences on the mother, or whether the conditions of the environment of the embryos are at fault.

The spawning season is so short and the period is so long that must elapse before the result of an experiment can be known, that only a little progress can be made from year to year. The attention necessary to be given to details and the care that should be bestowed upon each experiment are so pressing, it becomes impracticable to run several experiments simultaneously, because each will suffer from neglect while the others are engaging our attention.

THE APPARATUS.

At the opening of the season we planned and secured the construction of a breeding box, which fulfilled the following necessary conditions. It must be an enclosure, not so large that the fry cannot be found again for study, nor so small as to crowd them. It must permit of the ready influx and efflux of water and yet have pores so fine that the fry shall not escape, or that outside "natural" fry enter. It must be capable of being floated and enduring in waters of the same character as those covering oyster beds. Finally, it must allow the growth of oyster food within.

Considerable investigation had been expended in securing a cloth so regularly and so finely woven that its pores were smaller than the oyster embryos. Bolting cloth is too coarse meshed. Finally, we

found two fabrics that seemed suitable, viz., a felt and a material sold for window shades, called "hollands."

These fabrics were stretched upon, and tacked to, frames that screwed together, and that, when assembled, formed a box eighteen inches wide, three feet long and fifteen inches deep. Each box was divided into two equal, nearly cubical compartments, by a tight board partition in the middle, the ends being closed by similar boards. On the outside of each end, fastened crosswise a little above the middle, was a section of wooden pump tubing, four by four inches and eighteen inches long, with each of its extremities plugged up. This, together with the remaining wood served to buoy up the box so that eight to ten inches of water remained standing in it, having entered through the cloth sides and bottom when it was floated.

To keep waves from dashing over the top into these boxes, we devised a cover, consisting of a frame covered by cloth. But as we wished the boxes to float as high as possible, and as we wished as much light as possible to shine into the boxes to favor the multiplication therein of the microscopic plants that are the food of the oyster, the covers were not used during the past season. Practically no outside water was "shipped" except during the prevalence of unusually severe winds.

These boxes, after being protected by a lattice attached outside, were floated inside an enclosure or fence, constructed of small spiles ("oyster poles," etc.) driven into the mud. This not only prevented the boxes from floating off, but protected them from being run down by boats.

STATIONS.

These boxes were installed at the following localities: *First.* In the claire by the oyster laboratory at Tuckerton. This claire was emptied twice daily and filled by the upper and purer half of the tidewater that came from Great bay, near the natural beds, and then traversed up Big creek and Willets creek, over a mile of distance, to the mouth of Stopwater creek at the laboratory.

Second. In Elder creek, near its mouth, about a mile from the laboratory and a third of a mile from the mouth of Big creek. This box received practically the same quality of water as entered Big creek; but the incoming water had not been influenced by the mud

banks and tide-ponds of the "meadows" and creeks. This box had also been floated in Stopwater creek during the first half of the season.

Third. In Barnegat bay, near the northern shore of Conklin's island, nearly opposite the "Inlet," a quarter of a mile from the public dock, located at the mouth of the creek. Shells strewn in the vicinity received a fair catch of spat, the piles of the dock being particularly well covered with "spats."

Fourth. At Keyport, on the "Cliffwood flats," near the mouth of Oyster creek. The shells planted on these flats received a small catch of spat during last season.

There was therefore considerable diversity in the conditions surrounding these experimental plants, but the environment in each case seemed to offer no obstacles to the successful propagation of oysters. In all the places oysters flourished in the waters of the vicinity, and in the cases of Barnegat and Keyport natural spatting also occurred close to the boxes.

PRACTICAL WORKING.

On the whole, these boxes behaved as well as could have been expected. The water inside seemed to be as rich in oyster food as that outside. There was some doubt as to the contents being quite as pure as the outside water, because, while there undoubtedly was considerable dialysis, and also by reason of the waves some movement, there was nothing quite corresponding to the tidal flow, and so no true current.

Such tides can, of course, be secured by complicating the apparatus, or by constant attention. As we had to make the circuit of the Stations once per week, we could not give that much attention.

It was an "experiment" to see what would be the results under the conditions given, and if the results should be negative the experiments would have to be repeated, with variations.

Prolonged immersion in the sea water rotted the cloth, so that it finally ripped and had to be replaced. The felt lasted much better than the "hollands," and the durability was also inversely proportional to the violence of waves, tides and exposure to winds. At Keyport the tide rose and fell six to eight feet, and the north winds brought in choppy billows from the wide Raritan bay. At Barnegat the tide was less than two feet, and the narrow, shallow bay offered less opportunity

for northeast winds to raise heavy waves. At Tuckerton, although the tides were twice the height of those at Barnegat, the boxes, being in creeks, were not usually exposed to waves of serious force.

The box in the claire was covered with felt and lasted throughout the season. That in the creek was covered with "hollands" and lasted more than a month before requiring renewal. That at Barnegat consisted of two folds of "hollands" enclosing a layer of felt. It lasted about two months before breaking. That at Keyport was covered with "hollands" and lasted only two to three weeks. As the fry introduced should become attached and visible within this period, it was no serious interference with the experiment; but, of course, valuable time was consumed in making repairs.

OPERATIONS.

Spawn was secured from oysters in the vicinity of each plant, preferably from those that had not recently been handled by transplanting. The seed used consisted of natives—East River seed, Staten Island Sound seed and Virginias. The northern "plants" matured first, the southern ones later in the season. At Keyport it was doubted if the spawn in the southern seed ever attained proper maturity. The spawn was removed from the oysters immediately after their capture and the fertilization was made as expeditiously as possible. A special arrangement of hand microscope was devised for rapidly determining, while in the boat, the character of the spawn. All the experience of previous seasons was applied to have the fry as vigorous as possible.

Each box received a planting of fry at least once each week, only one compartment being used, the other remaining as "control," so that if natural fry should enter from without it would be discovered. Often a little of the freshly-fertilized spawn was poured into the box, in order that the developing embryos might have as normal conditions of temperature and water as possible from the start.

Usually we waited until after the swimming stage was reached and then made the experimental planting. At Tuckerton we sometimes kept the fry until the shell showed development and then planted the fry, so that they could secure food for further growth, because soon after the appearance of the shell the larva begins feeding.

We also carried fry, prepared at each station, to the others, and planted them. But very little could be hoped from such fry, as they were weakened through unfavorable influences obtaining during transportation.

Suitable cultch, consisting of shells, fragments of glass, bricks, wood, etc., was placed in both compartments of each box. This was examined about two or three weeks after the fry had been planted, and if nothing was seen, after using a magnifier, the pieces were washed clean and replaced. Some of the cultch was lost through ripping of the fabric and could not be secured for examination.

RESULTS.

With everything so favorable it was expected that a good set of spat would fasten to the cultch in our boxes, but these expectations were not realized. Something is still lacking; something essential and important still remains to be discovered. At Tuckerton there was no "set" of natural spat near the boxes. The outside of the boxes were well coated with barnacles at all the stations. At Keyport the shells near the box showed natural spats, but there was none attached on the outside of our box, where the conditions were quite favorable. At Barnegat the shells near the box showed a fair set of spats, and quite a few were attached to the bottom of our box. These had grown to a size several times larger than the spats on the shells lying on the mud below.

It seems evident that spawn artificially prepared lacks something to *enable it to grow into spat, or possibly there was an element lacking in* the boxes. These points must be investigated next season. The negative results may perhaps prove more valuable than would positive ones, and they will help us to secure the right answer—they will ultimately lead to the discovery of the secrets of oyster propagation. In every series of experiments we expect a hundred or more negative answers to one positive one. Indeed, for experimental purposes, the "nays" are as positive indicators as are the "yeas," because, until we have secured all these answers, both positive and negative, we have not learned all the principles that must underlie any successful application. We have constantly contended that no real progress can be made in application until the ecological elements of oyster develop-

ment are determined. We do not expect to raise oysters in experimental boxes for commercial ends, but such boxes are indispensable apparatus for determining the ecological principles. No doubt some progress could be made, and has been made, by directly experimenting with practical or commercial operations in oyster culture, but so long as such experiments fail to offer as many equations as there are unknown quantities, the latter will remain unknown. It is because "practical" men fail to realize this truth that they have so little sympathy with theoretical study. The details of our operations are given in the next section.

JOURNAL OF THE EXPERIMENTS.

May 10th, 1905.—We visited Barnegat and Tuckerton and sampled the oysters to ascertain the state of the spawn, and also prepared some for microscopical study. Returned May 12th and planned new and improved apparatus, which was completed June 3d and shipped to Barnegat and Tuckerton.

June 3d, Saturday.—Visited Keyport and arranged for an experimental plant there. Messrs. A. S. Van Buskirk, manager for J. & J. W. Ellsworth Co., Captain Wm. Wooley and others showed great interest and generously offered aid and facilities.

June 5th, Monday.—Proceeded to Barnegat. Next day set up the experiment plant on "shelling ground," of Captain Joseph K. Ridgway, in Barnegat bay, near the eastern shore of Conklin's island.

June 7th, Wednesday.—Reached Tuckerton. Late in the afternoon opened twenty-two oysters. Some of them were "Natives," some "East Rivers," but most were "Hog Islands." The majority proved to be males, and it looked as though some of the oysters had already begun "spawning." Selected half a dozen specimens of each sex and fertilized a lot of spawn. The weather was rather cool; the thermometer registered 60° F. Next morning the eggs failed to show any development; probably they lacked maturity. Established the experimental plants by assembling the boxes and floating the one with felt in the claire, the one with "hollands" in Stopwater creek, near the laboratory.

June 9th, Friday.—Prepared a new lot of spawn, which, though not fairly promising, was better than that prepared Wednesday. This was planted at once in the boxes, giving it temperature conditions

similar to those of the tidewater. Returned to New Brunswick and shipped an experiment box to Keyport, which was installed there June 12th.

June 14th, Wednesday.—At Barnegat, prepared a lot of spawn, which appeared quite promising. Through an accident nearly all of the best portion of this lot was lost; the remainder was planted in the box as soon as the embryos began swimming.

June 15th, Thursday.—At Tuckerton, prepared spawn from Hog Island plants and East Rivers, but the eggs did not seem to be ripe; most of the oysters proved to be males. Temperature about 70° F. during the night.

June 16th, Friday.—Thermometer 80° F. Secured some Hog Island seed from the pond, whose eggs seemed to develop better than those of yesterday.

June 18th to 21st.—Commencement at Rutgers College.

June 22d, Thursday.—Proceeded to Tuckerton, and next day opened Hog Island and East River oysters. The former were the better. Prepared a lot of fertilized spawn from a dozen good specimens of each sex. Thermometer 78° F. Next day, with a northeast storm, the temperature fell to 68°. The eggs had developed well and before night showed the rudiments of shells. Part of the fry was planted in the boxes; the rest was floated in the box, where the temperature of the water was 71° F.

June 25th.—Development proceeds nicely and more fry was planted. Prepared a new lot of Hog Island spawn, using two good males and four good females. Temperature 80° at eleven, 82° at one o'clock, 80° at six in the evening. Many of the eggs fail to develop. Planted part of fry and floated half of the remainder in the box, keeping the balance in the laboratory. Next day (70° F. at seven, morning, 88° at noon) the laboratory lots show development of the shell, not yet present in the floated lots. Planted some and bottled the balance, and transported them to Barnegat. The weather was extremely warm, so that the fry suffered.

June 27th, Tuesday.—At Barnegat, prepared spawn from oysters at the mouth of the creek—two males, three females. Secured a fair lot of spawn. The tumblers were floated over night in the edge of the creek to guard against chill, the temperature having suddenly dropped the previous night. A little of the spawn was planted at the same time. More was planted next morning and the balance was

bottled and carried to Keyport. Arriving at Keyport, found that the box was gone, the northeast storm tide of the 23d having lifted it over the enclosure, so that it sailed off.

June 29th, Thursday.—Found Staten Island Sounds, three years planted by Captain Wooley, to be in good spawn; so prepared a lot, using six females and two males. Discovered the lost box on Cliffwood meadows. Repaired and reinstalled the box, planting the fry therein Saturday morning, July 1st. The fence around the box was strengthened and made higher, so that the tide would need rise over ten feet to float the box out.

July 2d.—At Tuckerton, prepared a lot of spawn from "Natives" and "East Rivers." Rainy.

July 3d.—Temperature near 80° all day. At three o'clock a new lot of good spawn was prepared from six females and seven males. Seventy-six degrees at noon, 72° at 9 P. M. Some of this lot was floated, some placed in the laboratory and some was planted. The spawn prepared July 2d proved to be poor.

July 4th, Tuesday.—Yesterday's spawn has now reached the shell stage in fine condition. Temperature, 72°. Some of these fine embryos were planted and some kept in dishes until next day, when they, too, were placed in the experiment box.

July 6th.—Visited New Brunswick on business.

July 8th, Saturday.—Returned to Tuckerton. Next day warm and windy. In the evening prepared a new lot of spawn. Found nine oysters had completed spawning, and could use only one ripe female and four ripe males. The temperature of the creek water has now reached 82°.

July 10th, Monday.—Another hot day; 86° at noon. Yesterday's lot of spawn died before reaching the shell stage. Prepared new lot of spawn at 9 A. M. Secured only one fair female and five fair males. At 6 P. M. prepared a second lot from the East river plants, but secured only a half dozen poor and outspawned females and as many poor males. Floated this morning's and yesterday's lots in the claire, while I prepared a new enclosure for the box in Stopwater creek.

July 11th, Tuesday.—Planted some of the fry on hand and bottled the rest and took it to Barnegat. At Barnegat found the creek oysters had completed spawning, but there was abundant spawn in some large oysters that had been brought in from the bay by clammers. The majority of these were males. Prepared spawn at 9 A. M. The eggs developed rapidly and fry ready to plant was secured by 2 P. M.

July 12th.—Captain Ridgway secured a large female and a large male from deep water in the bay, and the eggs were fertilized at 8 A. M. and planted at noon. Some of this lot was carried to Keyport, where it was planted that evening.

July 13th, Thursday.—Went out into Raritan bay with Captain Wooley and found the Staten Island Sound plants nearly all spawned out. Prepared a lot of spawn, which was spoiled by overheating. So the planting grounds were visited again, this time on the watch-boat, and a new lot of eggs fertilized, but it was a rather poor lot. The Virginia "plants" were filled with spawn that seemed scarcely ripe, but I fertilized a lot at 2 P. M. After four hours both lots show swimming fry, that I mixed into one receptacle and kept over night. Next day a few (probably "Staten Islands") had reached a good shell stage, and they were planted. Next day fresh cultch was added in the box, and this was repeated Monday, July 17th. Very hot weather this day and the following.

July 19th, Wednesday.—At Barnegat a study was made both of the shells in the box and of those planted in the vicinity. Samples of "sets" were secured, photographs of some of which are shown on the plates accompanying this report.

July 21st, Friday.—At Tuckerton, found both the Hog Islands and the East Rivers contained abundance of excellent spawn. At 9 A. M. fertilized the eggs of eight females by the sperms of four males, and at 1 P. M. used six females and four males. Temperature of air and of water about alike—78° at noon—but air is colder at morning and at night. Discovered that the box in the creek had been torn by crabs. An examination of the cultch left in it and in the claire-box fails to show any "set" of spat. Restocked the claire-box with fresh cultch and good fry.

July 22d, Saturday.—Went to Barnegat and cleaned out the box and restocked it with cultch and with Tuckerton fry.

July 24th, Monday.—At Keyport, fertilized spawn from Virginia stock at 3 P. M. Part of this fry was ready to plant at 8 P. M., when I found the box ripped. Next day an extemporized box was prepared with hollands, placed inside the broken one and stocked with cultch and fry.

July 27th, Thursday.—At Barnegat, at 8:15 A. M., fertilized eggs from a well-filled female by the sperms of a fairly good male, both secured from a float up the creek. The oysters in a neighboring float

had finished spawning. No development of fry resulted from this experiment. Cleaned out the experiment box and put in clean cultch and several oysters. Continued the study of the natural "strike." Found the spat best, largest and most numerous near the shore and on the shady side of the shells, perhaps to be explained by the relative absence of algoid growth on that surface. Also found the spat most numerous where there was most current.

July 28th, Friday.—At Tuckerton, opened thirty-six oysters, which proved to be mostly spawned out. Selected ten fair males and six nearly empty females, whose eggs were fertilized at 3 P. M. Repaired the box in the creek and transferred it to Elder creek, a mile away, and close to the waters of Great bay, on Saturday. The temperature fluctuated between 70° F. and 80° F., and by Saturday night the fry showed the presence of developing shells. They were planted next morning in both the claire-box and Elder creek box. In the evening, while opening oysters for supper, I found six fairly good males, one half-spawned female and three with poor eggs. Prepared a lot of fertilized spawn. The temperature fell to 70° F., but the water was 75° F. At bedtime—ten o'clock—the fry was swimming.

July 31st, Monday.—The fry seemed to develop but slowly, and the shell stage is delayed. Next morning this lot was taken to Barnegat, where a strong northeast wind had caused the swamping of the experiment box. So I transferred this box to the lee side of the island, a quarter of a mile up the creek, and planted the fry in it. Found a fine catch of spat on the *Ulva* ("sea lettuce") off Cat island.

August 3d, Thursday.—At Keyport, found that a hole had been worn through the extemporized box. Examined shells planted July 3d by William Maurer, near the old brickyard. The "spats" were exceedingly few and were present mainly on shells placed on a wire platform and on the shell heap below the platform. There was no "set" on shells that had been planted late in July.

August 8th, Tuesday.—Found *Bucephalus* parasites in one of thirty-three oysters opened. All others were empty of spawn except that two males were half filled and a little spawn was present in four females. Fertilized the eggs at 3:30 and separated the swimming fry at 8:30. Thermometer showed 80° F.

August 9th, Wednesday.—Chilly southeast storm raged all day. The fry which had not reached shell stage was planted in the Elder creek box.

August 12th.—At Keyport; the "Virginias" had nearly completed spawning. A small amount of spawn was fertilized at 10 A. M. This was carried to New Brunswick to see if it would attain to the shell stage. We were stricken with a severe rheumatic attack and spent several days in bed.

August 22d, Tuesday.—At Barnegat, studied the oyster food (*"plankton"*) of the water. The creek was rich in *Peridinias* and the bay water swarmed with a spiral infusorian. Oysters were reported fattening up for market in fine shape.

August 24th.—At Tuckerton, study of water plankton shows presence of diatoms and *Peridinias* both inside experimental box and in the surrounding water. Having found my Barnegat box torn to pieces, I returned thither, dismantled and cleaned it and stored it in Captain Ridgway's houseboat. A severe storm prevented further study of plankton.

August 30th, Wednesday.—The boxes at the claire and Elder creek, near Tuckerton, were dismantled, cleaned and stored in the oyster laboratory.

September 6th, Wednesday.—The Keyport plant was dismantled, cleaned and stored in the Ellsworth Company's oyster-house.

From the above journal it will be seen that after July 30th no suitable spawn was obtainable, and we think it probable that only the spawn obtainable from June 15th to July 15th can be reckoned as suitable for purposes, unless in exceptional seasons.

DESCRIPTION OF THE PLATES (I. to XIV.)

FIXATION OF OYSTER SPAT TO CULTCH.
PLATES I. TO IV.

The various objects shown on Plates I. to IV. were planted by Captain Joseph K. Ridgway at Barnegat, at the mouth of the creek, at the western end of Conklin's island. Plates I. and III. show the side of the objects that lay uppermost on the bed, and Plates II. and IV. show the corresponding objects from the side that was lowermost. (Except *k*, which should have been laid the other side up in each plate.)

In some cases the objects were more or less tilted. The piece of bark shown at *a* was taken from a piling and was, of course, vertical. Naturally it has spat only on its outer surface.

At *b* is a clam shell which was buried in mud by its pointed end. Practically its entire catch of spat is on its upper, concave surface.

c is a platter with scarcely any spat on its upper, hollow side, but there is a fair catch on the lower side of its raised edges.

d is an oyster shell, showing spat caught the previous season, which died. No spat of last summer was caught on this shell.

e is a piece of unglazed red tile, which lay on the bottom with its hollow side down. It is almost evenly covered on all sides, but the spat on the lower or concave side has grown faster than the others. A few more spat caught on the under than on the upper surface, but the thickest set was on the vertical edges.

f is the deep and *g* the flat valve of an oyster shell. They were fastened together at the hinge (pointed end) and slightly gaped apart. The shell lay with the deep valve down. Scarcely any spat fastened to the under side of the lower valve. A few fastened to the upper side of the upper valve; a good many attached themselves to the upper side of the lower valve, especially on the upturned margins, but the greatest catch was on the lower side of the upper valve, as shown at *g*, Plate IV.

h is a broken glass flask, nearly evenly covered on all sides, except the part touching the bottom. Several spat fastened on the inside of the upper side, and these, as seen by their shadows, in Plate III., have outgrown the others.

i is a bit of glazed pottery which lay tilted, being held in the mud by the point and with the hollow side upward. This side received a fair catch, but the convex, nearly vertical, under side, shows some superiority as a spat collector.

k consists of the flat valve of an oyster shell cemented back to back to the deep valve of another smaller oyster. The large valve lay in its natural position, with its inner, smooth surface downward. (The views shown should be interchanged.) A little sediment was present in the hollow of the topmost valve. A good set of spat caught on the exposed portion of this valve; nothing caught on its under, rough surface; a few spat caught on the upper, rough surface of the large valve; but its smooth side, as seen in Plate III., was covered by more than two hundred spat.

l. A piece of crockery from the same pot as *i*, but with simple, cylindric curvature only. It lay on the bed with the convex side down and received a fine "catch" on the convex side of the upturned ends. On the upper side is a bunch of spat of the previous season that had died before winter, and a few new spat of the present season. Similar old spat on the convex side shows that the crockery lay in a different position the preceeding year.

Remarks.—While the general distribution of these spat seems to support the theory on which the French spat collectors are made, there are some important anomalies that prove that there are other factors that play a part. This subject we desire to experimentally test next season. The general belief is that oysters fasten to the under surface of cultch because that surface is protected from sediment.

As regards the cultch of which samples are here shown in photograph, Captain Ridgway informs me that they were planted June 15th, and that by July 10th they were well covered with spat. Those at the mouth of the creek grew so rapidly that by October 15th they were double the size of those planted alongside of the island, near our experimental box.

Their rapid growth was ascribed to the strong tidal currents at the mouth of the creek. Captain Ridgway began to remove them to planting grounds in Gunning river about September 25th, but was forced to stop after working two days, as it was found that the crabs were eating them up "about as fast as they were planted." Of those planted two days before, not one in fifty was left alive. He says:

"Since the water got cold enough to force the crabs into winter quarters, we have planted over 1,000 bushels, and have yet more to plant. Owing to rapid growth the shells were very thin and the large crabs gathered on them by hundreds, and could easily crush the oysters with claws and teeth.

"This is not the first instance that we have known the crabs to kill the spat, but they do not harm them so much if the plants are left on the spatting grounds until cold weather. In handling young oysters many of them are broken, and the crabs are first attracted by those, and when they are eaten they begin to work on the others, and will often kill oysters that are two years old if the shells are thin.

"On the shells planted for the State there is an immense set of spat. From those planted in June, 1904, there have been thousands of bushels of first-class seed oysters taken. On October 2d, 1905, there were about 500 men working on these shells and they caught from twenty-five to fifty bushels per man. On the 3d about 250 men were at work and caught twenty-five bushels per man. More would have been at work on the beds, but they had filled their boats and were busy planting in Tuckerton bay.

"A number of men will work on those beds each fine day until May, 1906, and yet some one, for political reasons, will swear that shelling the depleted beds by the State does not pay. On shells we planted in June, 1905, there is a fine set of spat, and if they are properly guarded will furnish a fine lot of oysters, October, 1906."

Inquiry of Watson T. Sooy, clerk of Burlington county, who is an interested partner in an experiment on Mullica river, elicited the following information: "Several large ditches had been completed in 1904, in the meadows of Mullica river, and in the past summer were shelled. All the ditches had a light catch of oysters, but they grow very much faster at Swimming-Over than up the river. We have reserved one ditch for experiment and propagation."

GENESIS OF OYSTER SPAWN.

PLATES V. TO XIV.

The remarkable conditions presented by the spawn of different oysters at different times during the season offers a set of most interesting problems, whose elucidation I have not a particle of doubt will help us, and probably will be necessary, to be successful in artificial oyster propagation. We have therefore, in the present season, continued our histological studies, begun last year, by investigations of the genesis or growth of the spawn within the oyster itself. Plates V. to XIV. are drawings of sections, greatly magnified, of the reproductive glands of our oysters during June and early July. The last three plates represent sections through the male gland or spermary, showing the genesis of the sperms. The remaining plates show sections through the ovary and exhibit the development of the eggs or *ova*. It will be noticed that in early June or late May the epithelium cells lining the inner side of the egg tubes begin to multiply and to bury down into the tissues of the ovary, and so produce branched "follicles" that empty into the egg tubes or oviducts. In these follicles the cells multiply and grow at the expense of the large cells that previously constituted the ovary. These cells are of the same nature as the "fat cells" of the lips (*palps*) and other parts of the oyster. They are the part of the oyster that makes it worth eating.

All these "fat cells" lose their nutriment and it is all transferred into the germ cells that fill the follicles. Then after a time this food supply gives out and the germ cells begin feeding on one another. The strongest survive and finally the follicles are filled with relatively big cells or eggs, containing all the nutriment in the oyster. Such oysters, filled with spawn, make an excellent stew if fresh, and in our coast cities, and also in Philadelphia, but not in New York, are regularly eaten in the "r-less" months of summer.

When, however, the spawn is thrown out into the water for propagation purposes, the oyster is lean and worthless for food. Our northern oysters are "in spawn" for so short a time that the trade in summer oysters mainly relies on southern plants, which, when transplanted to northern waters, fill up with spawn, but do not find the temperature of the water rising to the limit to which they have been accustomed in their native home, and so they retain this spawn, as at Keyport,

practically all summer, or until the northern oysters have become restored in fatness, in September.

These wonderful changes in the ovaries and spermaries of oysters do not take place with accuracy, but often go wrong, and then the spawn is worthless for purposes of propagation. Until we can accurately determine that the spawn in hand is properly ripe, we shall lose much time and make many futile experiments. Hence we must push this aspect of our studies for the present.

In all the figures the letters denote as follows:

a. Centrosome.
c. Cilia.
cs. Chromosomes.
ct. Connective tissue.
d. Germinal *debris.*
ec. Embryonic connective tissue.
ep. Epithelium.
F. Follicles.
G. Germ cells.
n. Nucleus of eggs.
nu. Nucleolus.
od. Oviduct or egg tube.
Pa. Parenchyma of reproductive gland.
Ps. Parenchyma of skin or "fat cells."
S. Sperms.
Sd. Sperm duct.
Sb. Sperm balls.
V. Blood or lymph vessel.
× indicates the amount of magnification of the printed cut.

Except when otherwise stated, the specimen was prepared by being hardened in formol-alcohol, imbedded in paraffin, sectioned by microtome and stained in Gage's hæmatoxylin on the slide, and final mounting in Canada balsam, and projection with a camera lucida, using a water immersion objective for all powers over 300 diameters. As all the drawings have been reduced one-half in preparing the electrotypes, the actual power used in studying the sections was more than that indicated on the figures, but not twice as great, because the drawings were enlarged by the projection.

The sections have generally been cut perpendicularly to the surface of the body, and either longitudinally to the egg tubes or across them. The figures have been arranged on the plates so that the edge of the section nearest the surface of the oyster is either at the top, or at the left side when it was impractical, from the shape of the drawing, to place it in the former position.

PLATE V.

Figure 1. Section of an ovary at an early stage of follicle formation. Several follicles containing germ cells are seen burrowing down from the oviduct (*od*) into the parenchyma (Pa).

Figure 2. Enlarged view of a young follicle a little earlier than those shown in Figure 1. The germ cells G show a large granular nucleus with only a small amount of cytoplasm. They are not very unlike embryonic connective tissue cells that lie between the parenchyma cells of the ovarian stroma.

PLATE VI.

Figure 3. View of a reproductive gland, in which there is a heavy reticulum of embryonic, connective cells. As these resemble the young germ cells, it is possible that our identification is erroneous, and they may prove to be abnormal germ cells. Compare Figure 6, Plate VII.

Figure 4. Section of the ovary in another oyster, in nearly the same stage as 1.

Figure 5. Enlarged view of the cross-section of an oviduct (*od*), showing what appears to be ciliated epithelium on its roof and proliferating germ cells on its floor. In the center is a mass of broken-down cells (*d*), whose origin is not clear. The germ cells have already begun to grow at the expense of the surrounding tissue. They have become irregular in outline, possess pseudopodal processes and can, in most cases, be distinguished from the embryonic connective tissue (*ec*). The upper end of a follicle is shown at F.

PLATE VII.

Figure 6. Enlarged view of a portion of the section shown in Figure 3. At G is a mass that cannot be distinguished from the normal germ cells. The so-called nuclei of "embryonic connective tissue" seem to lie in a network of cell protoplasm with indistinct boundaries, forming almost a *syncytium*. But at this stage the germ cells also simulate such a condition.

Figure 7. Cross-section of a germ duct and the root of a follicle, to show the chaotic condition into which the germ cells may pass while they are absorbing nutriment. At this time the parenchyma cells have partly disappeared and the germ cells are struggling to absorb one another.

PLATE VIII.

Figure 8. Cross-section of a similar oviduct at a later stage, when certain of the germ cells have conquered their neighbors and are definitely enlarging to form eggs (E). A considerable amount of parenchyma still remains.

Figure 9. A moderately enlarged view at a later stage, to show the ramifications of a follicle. The germ cells have now arranged themselves definitely along the walls of the follicle and have begun to absorb the remaining parenchyma. Compare Figure 10.

PLATE IX.

Figure 10. A moderately enlarged view of a section through an oviduct and adjacent follicles, a portion of which is enlarged in Figure 8.

Figure 11*a*. Section lengthwise through an egg follicle when all the parenchyma has been absorbed.

Figure 11*b*. Enlarged view of adjacent walls of a part of Figure 11*a*. Only the embryonic connective tissue cells lining the follicles now separate them.

PLATE X.

Figure 12. Enlarged view of adjacent follicles in a portion of the ovary where absorption is not yet completed. A few large, nearly ripe eggs (E) are seen, with their nuclei (*n*) and nucleoli (*nu*); also two parenchyma cells (Pa) not yet absorbed; also the *debris* of germs cells (*d*) that have nearly been absorbed to feed their greedy and stronger neighbors.

Figure 13. An enlarged view of two adjacent follicles a little more mature. The connective tissue (*ct*) between the follicles is quite strongly developed in places.

PLATE XI.

Figure 14. View at the edge of a ripe ovary, showing the development of eggs, here, quite behind that in other parts of the ovary.

Figure 15. General view of several follicles in cross-section of same ovary, as shown in Figure 14.

Figure 16. Enlarged view of a cross-section of one follicle from Figure 15. There is still some *debris*, and spawn taken from the ripest oyster generally shows some *debris*. But the ripening has not been perfectly completed unless such *debris* is reduced to insignificant proportions.

PLATE XII.

Figure 17. Section showing follicles of the spermary or reproductive gland of a male oyster.

Figure 18. A view corresponding to that of Figure 6.

Figure 19. A similar view drawn from a carmine-stained section. Here the cell bodies are more plainly indicated. But while we have to deal with connective tissue in general, there seem to be collections, as at G and E, of germ cells. It may be that this condition is one of involution and that the spawn has nearly been absorbed, the connective tissue growing, and some of its cells swelling, to become new parenchyma.

PLATE XIII.

Figure 20. Enlarged view of a portion of Figure 17. Next to the follicular walls we see the innumerable cells containing large, granular nuclei (*Sb*) and in the center of the follicle lie smaller cells (*S*). The latter are produced by the splitting up of the former.

Figure 21. Greatly enlarged view of the sperm balls (*Sb*) and the resulting smaller cells (*S*) produced from them.

Figure 22. Moderately enlarged view of two adjacent follicles of a nearly ripe male oyster. F′ and F″ point to the walls dividing the follicles.

Figure 23*a* is an enlargement of the central part of Figure 22, showing sperm balls (*Sb*) lying next to the follicular wall and sperms (*S*) nearer the middle of the follicle.

Figure 23*b*. Shows, greatly enlarged, the sperm balls and sperms of the same section.

PLATE XIV.

Figure 24. Section through a spermary not yet fully ripe. The sperm balls still line the walls of the follicles, but the latter are greatly distended by vast numbers of sperms.

Figure 25. Enlarged view of two adjacent follicles of same section.

Figure 26. Greatly magnified view of some sperm balls and sperms of this section.

The exact number of divisions that the sperm balls undergo before the sperms are fully mature has not yet been determined. The particles marked *S*, and here called sperms, may yet possibly divide into two, each sperm having then only two chromosomes. The sperm balls seem to split up into four parts at least once.

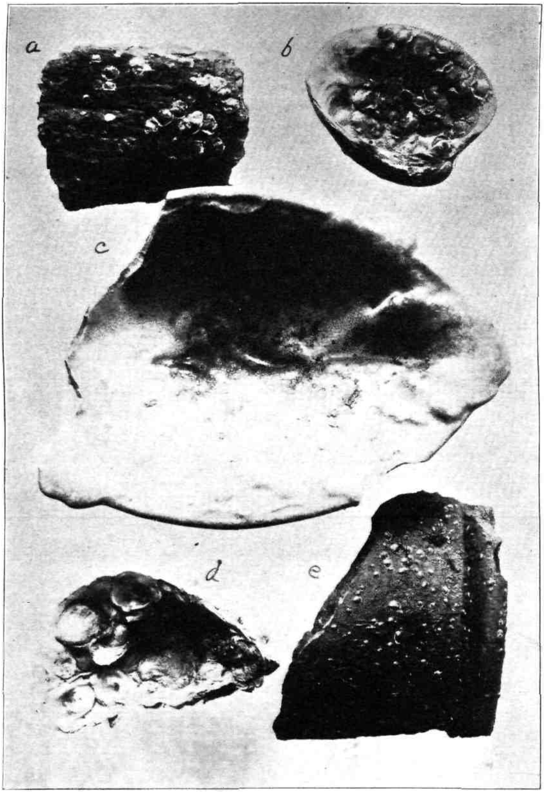


PLATE I.
Oyster Cultch, upper side.

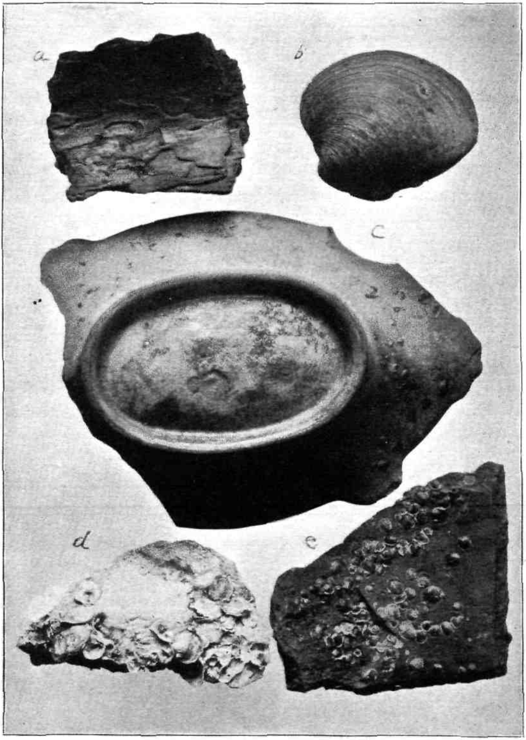


PLATE II.
Oyster Cultch, lower side.

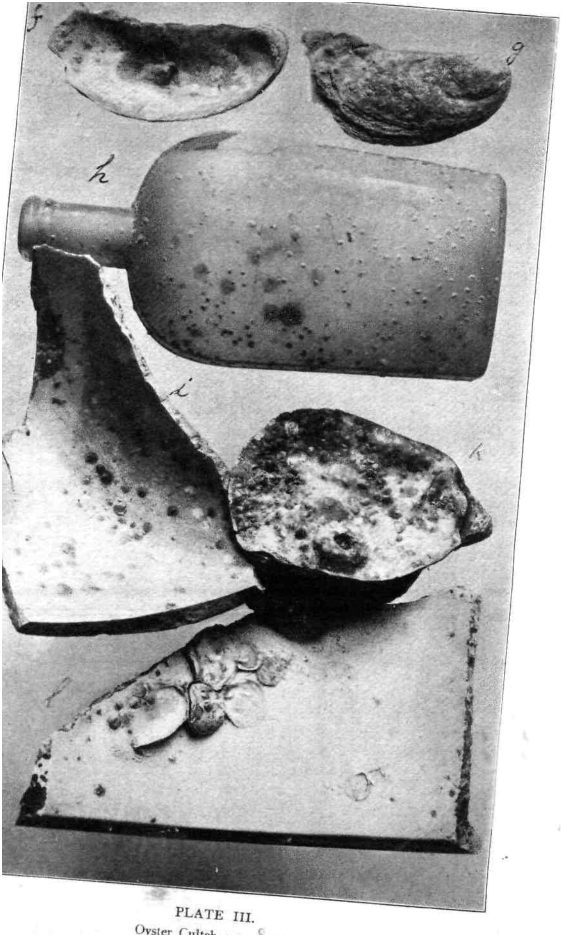


PLATE III.
Oyster Cultch, upper side.

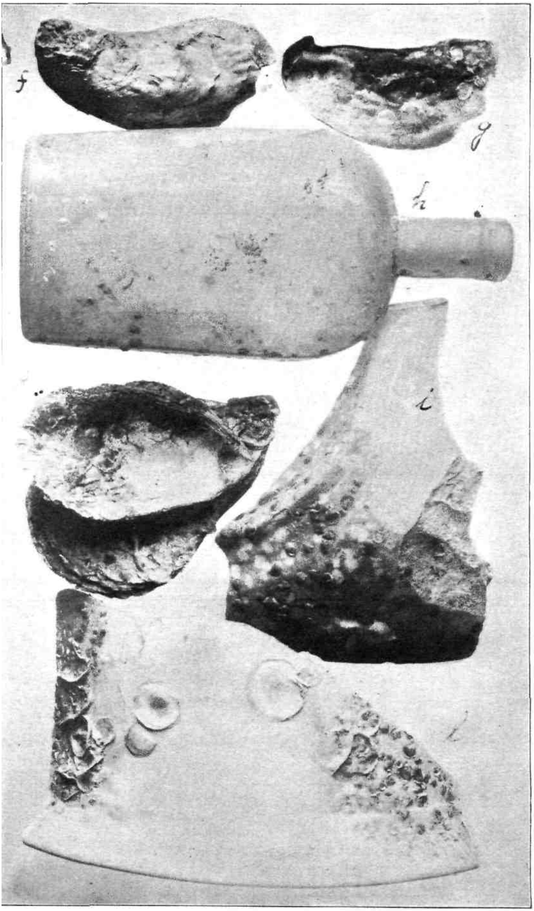
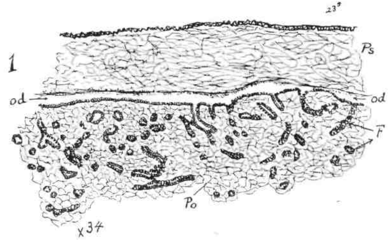


PLATE IV.

Oyster Cultch, lower side.



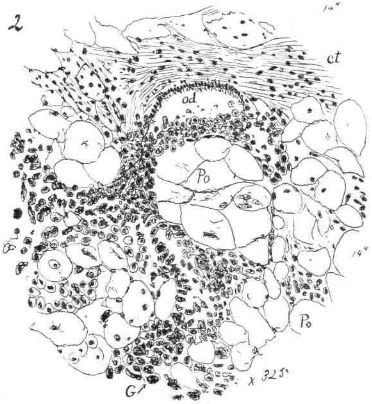


PLATE V.
Genesis of Oyster Spawn.

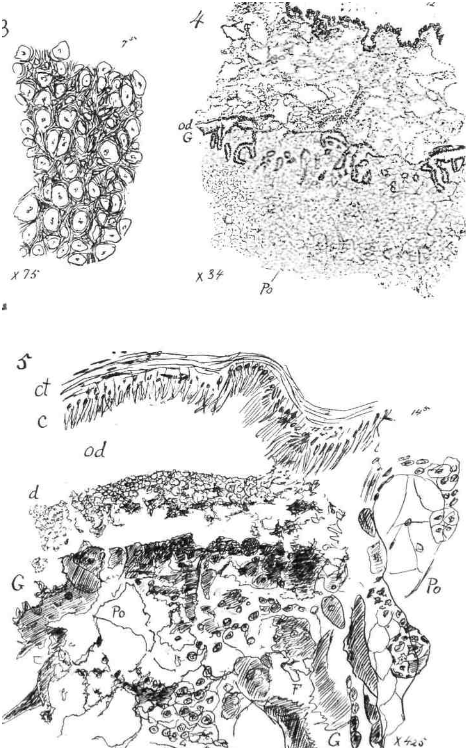


PLATE VI.

Genesis of Oyster Spawn.

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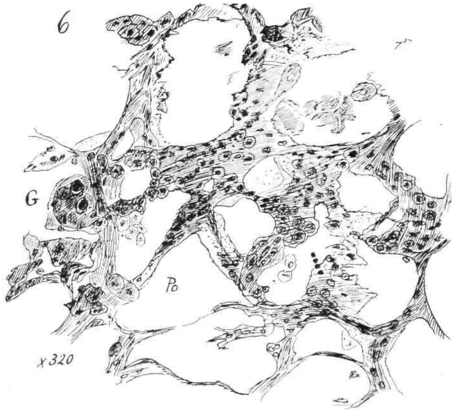

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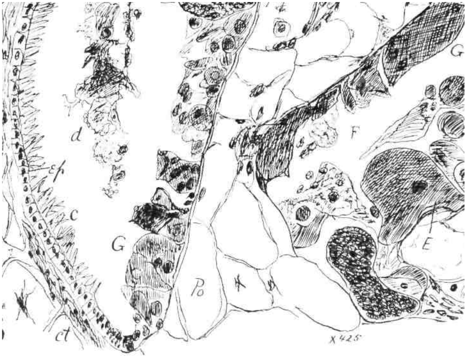
PLATE VII.
Genesis of Oyster Spawn.



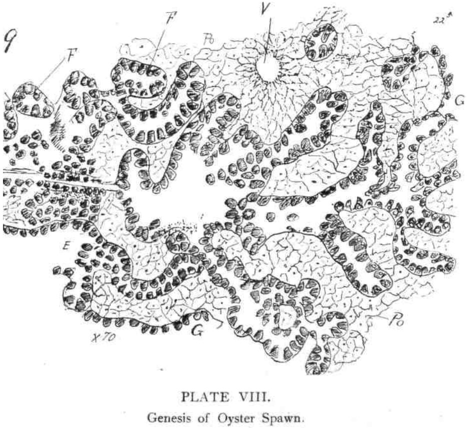
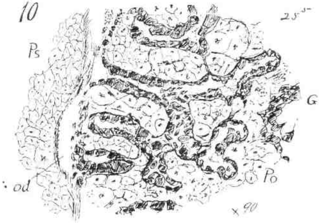
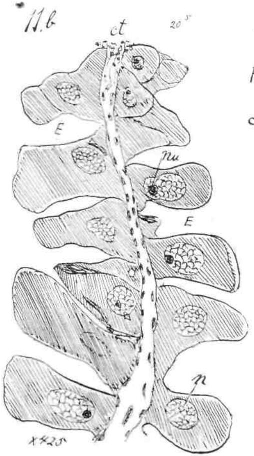


PLATE VIII.
Genesis of Oyster Spawn.





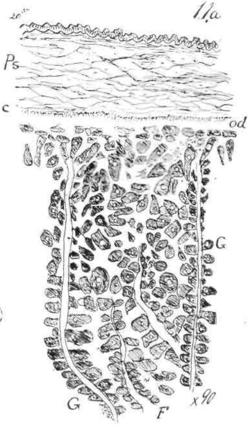


PLATE IX.

Genesis of Oyster Spawn.

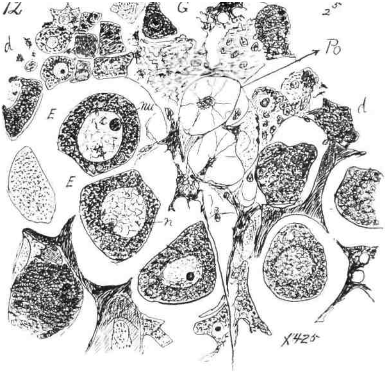


PLATE X.

Genesis of Oyster Spawn.

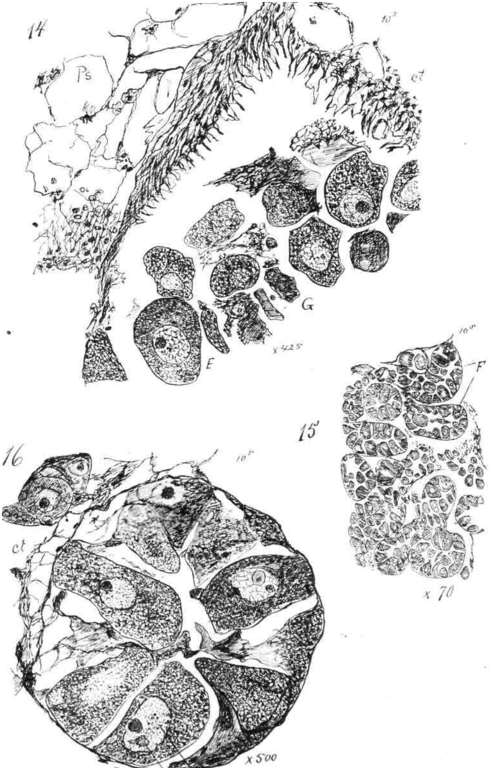


PLATE XI.
Genesis of Oyster Spawn.

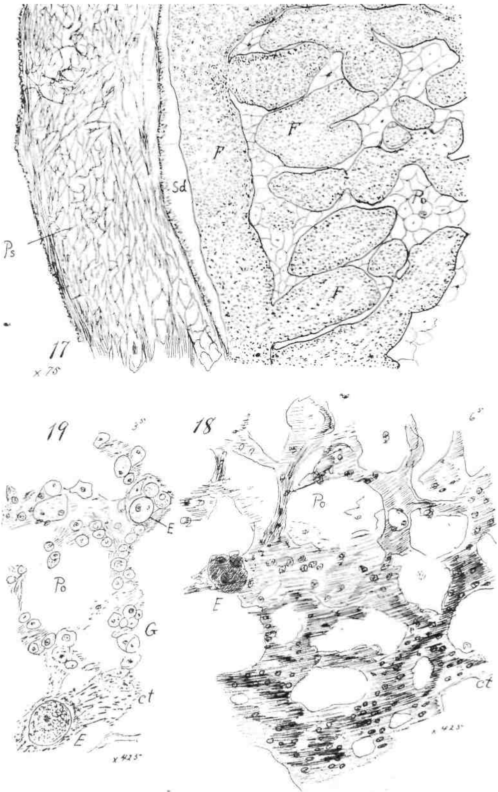


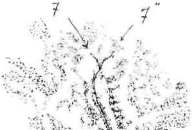
PLATE XII.
Genesis of Oyster Spawn.

20.

21

23, b

22



23, a

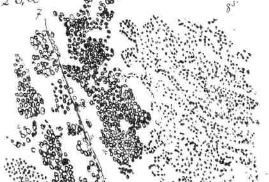
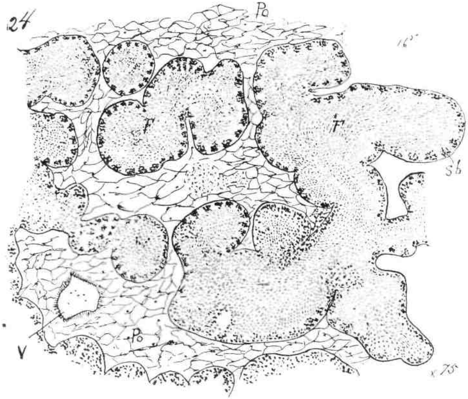
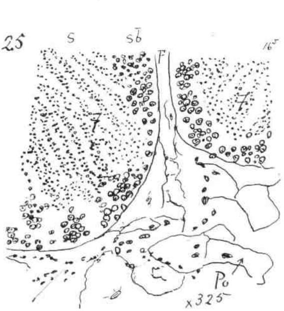


PLATE XIII.

Genesis of Oyster Spawn.





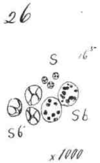


PLATE XIV.

Genesis of Oyster Spawn.

REPORT OF THE BOTANIST.

further developed. A hybrid between the "Scarlet Chinese" and the *ordinary eggplant was fruited.*

A long list of new crosses of bush beans of both the green pod and wax sorts was grown for their first and second generations, and some progress was made in the selection of the bush lima beans.

A large portion of the Gardens was occupied with the new crosses of tomatoes, some of which are full of promise. From blocks of certain former crosses a good supply of seed has been saved for distribution. Of these is a cross between "Ponderosa" and "Magnus," the "Magnerosa." In addition to this a long list of the best sorts was grown and also a number of the novelties of the year. A fresh supply of seed of the "Station Yellow" tomato has been grown for further distribution.

The experiments with hybrid salsify have been continued and some results were obtained from the breeding of ornamental plants.

Bulletin No. 179, "Free Distribution of Experiment Station Seeds," of twenty pages and four page-plates, was published December 20th. As a result seed packets to the number of 872 were sent out, chiefly to the crop-growers of the State. This does not include the large number of samples of crossed seeds that were placed in the hands of scores of truckers and others for special tests, reports upon which cannot be given for another year.

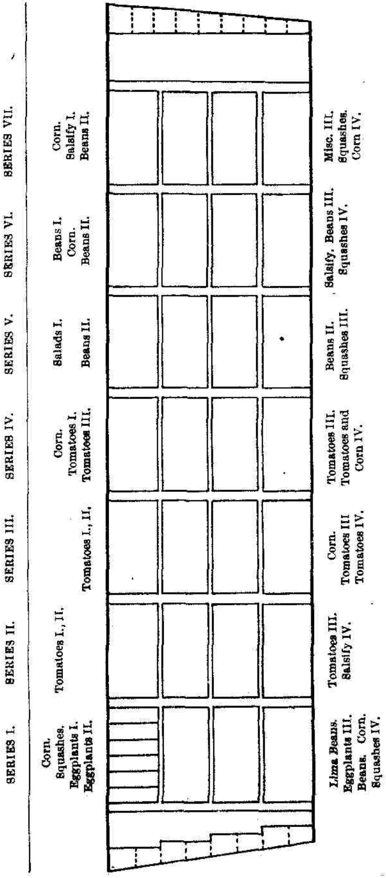
The work with the beans, eggplants and summer squashes has been in immediate charge of Mr. E. J. Owens, and that of tomatoes and winter squashes of Mr. J. K. Shaw, up to the time of his resignation.

THE EXPERIMENT AREA, OR GARDENS.

The plan of the Gardens is given upon the adjoining page. They consist of two acres, divided into seven series, with four plots to each series. Paths, in sod, four feet wide separate the series, while two-foot walks run lengthwise of the grounds and divide the plots. There are twenty-eight plots, each thirty-three by sixty-six feet, each a twentieth of an acre, to which is added an irregular block of ground at each end of the regular set of plots, as shown in the plan.

The soil is fairly uniform in quality, it being a mixture of clay and gravel, and at the outset was not of the best for garden purposes. Its texture has, however, been much improved by the annual application of stable manure, at the rate of twenty tons per acre, for the past eleven years. A small amount of commercial fertilizer has been used, for the first time the present season, where a second crop, as of beans or squashes, has been grown.

The Experiment Area for 1905.



SWEET CORN UPON THE HOME GROUNDS.

Space upon the two acres in the Experiment Area did not permit of more than ten blocks of sweet corn, and with these early and late sorts needed to be so adjusted that as wide an interval as possible might be between any that bloomed at the same time. The first to be planted were the two breeding blocks, the one of "Malakhov" upon "Premo" and the other "Malakhov" upon "Crosby." The "Malakhov" has shown itself, in our climate, to be a very early sort of superior quality, but too small to be of much market value, and attempts have been made to increase its productiveness by uniting it with other sorts of recognized merit in productiveness. The "Malakhov," with us, carried ears ready for cooking by the 10th of July, while the "Premo," planted in alternate rows with it, was five days later. There is a much greater difference in the time of maturing the grain. A second planting with seed of this season's growing was made of the "Malakhov" upon August 1st, at which time the "Premo" was scarcely out of the milk. This second crop gave good roasting ears.

It may be said that the difference in time of blooming did not materially affect the securing of the cross because all of the earlier ears of the "Premo"—the ones most desired—were in season for the pollen of the largest stalks of the "Malakhov."

To anyone wishing to try his hand in breeding corn, it may be written that the work of breeding one sort upon another is very simple, provided that the blooming period is common to both and the tassels are all removed from the stalks of the female parent of the desired cross. This last requires attention at least once a day, and the tassels may be pulled when they are just emerging from the coil of leaves by grasping the young stalk well down with thumb and finger and giving a twist as the tassel is lifted. These tassels should be removed from the field, and it is a satisfactory practice all around to turn them over to a pet horse or cow for their enjoyment and digestion.

The bane of the breeder of corn, when the alternate-row and detasseling method is practiced, is the "sucker." It comes like a thief in the night, and before the tyro is aware its pollen has been spread by the morning breezes and done its work beyond repair. There is no safe rule with "suckers" save that of intolerance. They must be removed from the hills while they are still small, during any of the early hoeings of the breeding block, and from all the hills, whether of the pro-

posed male or female parent of the cross. It is ear capacity, and not fodder tendency, that one is after in breeding sweet or table corn.

The ears of "Premo" thus secured all carry crossed grains, that the following season may be expected to produce corn that, in size of stalk and ear and earliness and sweetness of grain, will be a mean between these qualities in the parents. In this instance the stalk will be of fair height, the ear of good size—sometimes eight-rowed, like the male parent, and often more like the seed parent. The quality should be satisfactory and the productiveness good for such an early corn. A small block of this cross will be grown upon the home grounds for testing and selection to a type, but the main portion is available to those who may wish to test it under certain restrictions that may be imposed when the seed is distributed.

The second breeding block for corn was occupied with alternate rows of "Malakhov" and "Crosby" distantly situated from all other blocks of corn then in bloom. In fact, these two blocks above mentioned had the only ears in bloom at the same time, and only the "Malakhov" in these were permitted to produce pollen, and therefore the cross is practically pure.

In the case of the "Crosby" block the difference in time of blooming was fully a week—that is, the silks of the "Malakhov" were ready for pollen seven days before those of the "Crosby" were mature. However, many of the stalks of "Malakhov" produced tassels late enough to impregnate the "Crosby," save in case only of a few very slow-growing stalks that were by their delay fortunately eliminated, because the breeding was for earliness, in connection with the superior qualities of the "Crosby."

The seed thus secured is for free distribution to those who are willing to take the pains to isolate the plants from all other kinds of corn, and enjoy the added interest of having a new sort of sweet corn form under their care. In the present instance certain stalks were marked with wire labels when they were in silk, and this may be taken as a suggestion that the selecting of the ears for seed should be made early in the maturity of the plant. To use the best for the table is a poor rule when one looks ahead to future years. It requires but a little for planting, and by all means let that little be the best in every way. Favor the marked plants by removing the others from the hill. Select and then give the selected specimens the best opportunity for growth.

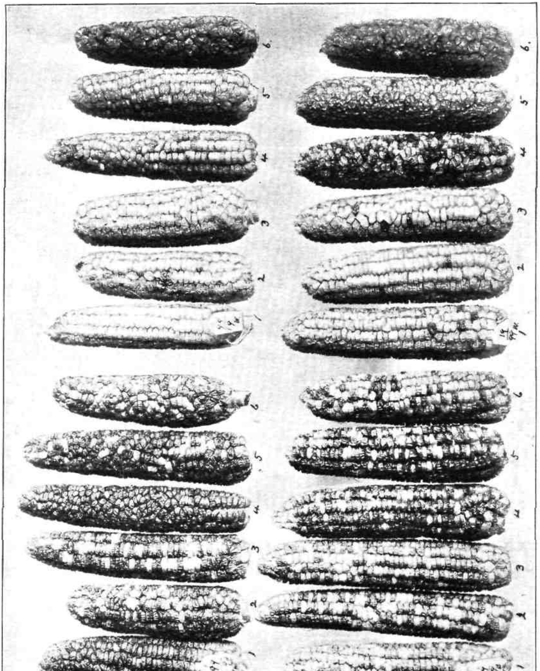
The "Black Mexican-Country Gentleman" Crosses.

Four blocks upon the Home Grounds were devoted to the crosses between the "Mexican" and "Gentleman" crosses of sweet corn. There were two in which the cross was with the "Mexican" as the male parent, namely, one planted with the black grains in this cross and the other with the white grains. Thus, by referring to the report for last year (1904) it is seen that of this cross—first generation—practically three-fourths of the grains upon any ear were dark and the remaining ones white. This is in accord with the law in breeding that was discovered by Mendel, and bears his name.

The two plots, while planted upon the same day, and so far as possible receiving like treatment, were not alike in soil and situation, being upon opposite sides of the trial grounds, and therefore the plants themselves were not strictly comparable. One block was upon land that was much better able to bear the long dry spell than another.

"Mexican" upon "Gentleman" (Black Seed Grains).

The crop from the dark grains of the above cross ("Mexican" upon "Gentleman") ($\frac{99}{19}$) is quite uniform, as is shown in the group of six ears in the upper left-hand corner of Plate I. There were many eight-rowed ears and several of them were solid black—that is, carried no white grains—while others were ten and twelve-rowed, made up entirely of black grains, as shown in the ear at the left of the set of six. There were no ears of strictly the "Country Gentleman" type, but several had the grains zigzag throughout the upper half. The ear at the extreme right of the set is a fair representative of the exceptional type in question. A solid black ear, showing strongly the "Gentleman" blood, is to be seen at No. 4. The three ears to the left favor the "Mexican," and the three to the right the "Gentleman" type. The amount of white grains is fairly well represented in the plate, for those thus marked have more than the average, while two—that is, No. 1 and No. 4—are solid black. A count of the grains from ten representative ears gave 3,095 black and 611 white grains, which is not far from the theoretical numbers for the third generation, when the colors obey the Mendel law of heredity, there being 83.57 per cent. black and 16.43 per cent. white.



It should be stated that this crossed corn is entirely unlike the "Voorhees Red," made in a similar way of breeding the "Mexican" upon the "Egyptian," another white sort. In the present case the color of the dark grains is as black as those of the true "Mexican," and as a result the final cross, when the white grains are all eliminated, will be doubtless an ear with black grains, but, of course, having a blending of many other qualities of the two parents. Just why the result is not a red here, as with the "Voorhees," it is left for further experiments to decide.

It seems possible, by further selection and breeding from the crosses here shown, to obtain a variety that has the rows of a well-defined number and another of the true zigzag type of the "Gentleman"—that is, black grains from the solid black ear No. 1 might perpetuate its type, while those from No. 6, it would be expected, will produce the peculiar flattened and slightly curved ear of the "Gentleman" with the grains numerous long and disposed without order.

"Mexican" upon "Gentleman" (White Seed Grains).

The group of six ears in the upper right-hand corner of Plate I. illustrates the results obtained from planting a separate breeding block with the white grains obtained from an ear of the above cross as grown the previous season. The land where this lot of corn was raised was not quite as good as that of the corresponding black set, and on account of the very dry weather the ears are doubtless much inferior to what they would otherwise have been. The whole lot of a hundred or so of ears is practically white throughout, with the exception of two small ears that show perhaps one-quarter of black, suggesting that the grains planted carried the black quality, but so obscured as to escape detection at the time of planting. As in the previous group, the left three show the rows of grains distinctly, and they approach more nearly the form and arrangement of the grains in the "Mexican" than the three upon the right. The only ear that had the grains placed zigzag throughout is shown at the extreme right. It is seen that from ear No. 1 to No. 6 there is a somewhat similar set of variations as shown in the companion set, but here the grains are practically all white, and no further work is needed to get the color uniform. Here, again, there is hope of obtaining two types of ears by selection and breeding. It remains to be seen whether

a white "Mexican," so far as the ear is concerned, can be procured, with all the sweetness of the famous dark variety, without its chief objection, namely, the black color.

"Gentleman" upon "Mexican" (Black Seed Grains).

In the lower left-hand corner of Plate I. is shown a set of six ears selected from the crop resulting from the planting of the dark grains' "Gentleman" upon "Mexican" ($\frac{19}{99}$) of the previous year. The half-bushel and more of ears are quite uniform, all having the black predominating and all adhering quite closely to the "Mexican" type—that is, there were no ears that had the grains placed zigzag, as in the "Gentleman." It is worthy of remark that the "Mexican" has impressed itself so thoroughly upon the cross, and were it not for the large, stout ear, with usually ten to twelve rows, and, of course, the many white grains, there would be very little to suggest the "Gentleman" parent.

It may be well to dwell for a moment upon the history of the black grains that have given this season the ears that are in question. In 1903 white grains were obtained upon "Mexican" ears that were grown close to the "Gentleman." Ears with these white grains are shown in Plate II. of the report for 1903. These white grains, when grown in a block by themselves, gave ears last year that were nearly solid white, *as shown in Plate I. of the report for 1904. It is these dark grains that have produced the ears in question. It is possible that the dark grains of a year ago were from "Mexican" pollen outside* of the block—that is, from the block planted with dark "Mexican-Gentleman" grains—and that the result of the present season is one of a secondary cross and might be expected to give ears with three-fourths of black grains. A count of ten typical ears shows the number of the two colors of grains as follows: Black, 2,398; white, 1,098—or 68.59 per cent. and 31.41 per cent., respectively. It seems evident that there was white "blood" in the dark grains used for seed.

"Gentleman" upon "Mexican" (White Seed Grains).

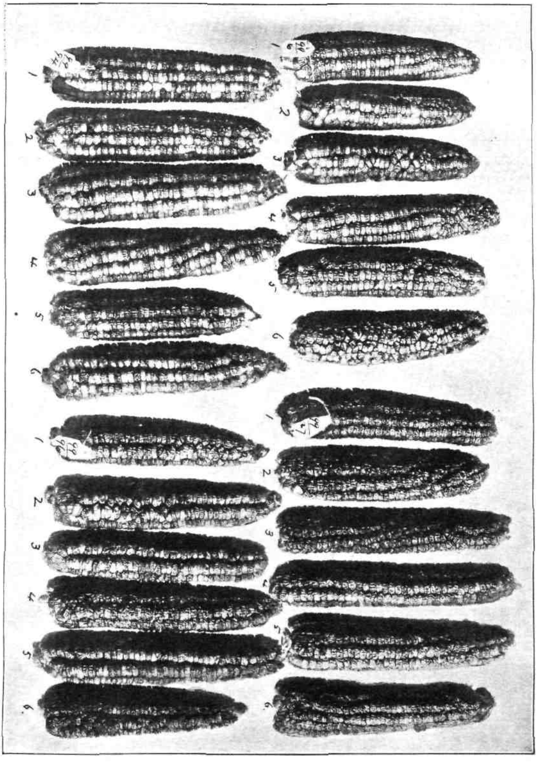
By far the most satisfactory block of the four in this set of double reciprocal crosses is the one from which the set of ears is shown in the lower right-hand corner of Plate I. Considering the unfavorable season the yield was fine, and the bushel of ears are of two leading types, namely, those with the rows distinct and those having the grains placed zigzag. The three ears to the left show the former characteristic, while the other three are manifestly "Gentleman" in type. Several of the ears show solid white grains and none of them show more than the few in five of the ears in the set in question, excepting six, which were strongly marked with black, as shown in ear No. 4 in the set. The explanation for this seems to be that these ears came from grains that carried the "Mexican" blood, but so obscured as to escape detection at the time when the grains were selected for seed. If this be true, it is reasonable to presume that all the dark grains in the whole block came from these few sources of contamination. Had the seed grains all been truly white, it is safe to predict that the whole block would have been white and the variety established, so far as the color of the grains is concerned. A count of the grains upon an average of the mixed ears showed 220 black and 210 white grains. If the seed planted was half white and half black, it follows, owing to the dominant quality of the black color in mixed grains, that it would require that all the pollen of the whole block of stalks should be of pure white blood to bring the ear in question to a mixture of half and half. The small percentage of mixed stalks that produced mixed pollen is enough to account for the slight excess of dark or light grains upon the ears in question.

Out of this lot of ears it is possible to select, with reasonable hope of securing a (1) "White-Mexican" and a (2) "White-Gentleman." The former would have plump twelve to fourteen-rowed ears of a very desirable size and shape and quality, with the grains long and the cob correspondingly small. The latter might result in a zigzag variety, with earlier plants and finer ears than the original "Gentleman." The possibility of fixing a type with only the upper end of the ear zigzag, as shown by No. 3, is not beyond consideration, should such a form seem desirable.

First Generation of Four New Crosses.

A block in one corner of the Gardens was occupied with fifty hills of "Mexican" upon "Banana" ($\frac{99}{6}$) planted early, and alongside of it, but planted three weeks later, was a quantity of "Mexican" upon "Striped Evergeen." The male parent, while the samé in both, was mated in the first instance ("Banana") with very early sort, and in the other a medium-late kind of the evergreen group. The difference in time of planting was not quite sufficient and the "Mexican-Banana" plants were detasseled as soon as their ears were served. All suckers had been previously removed. A number of the earliest plants in the adjoining "Mexican-Striped Evergreen" block were also detasseled to prevent their possible mixing with the latest of the former cross. In ordinary seasons these precautions would probably not have been needed, but the prolonged drought hastened the blooming of all plants like corn, and particularly the later sorts. It is, however, better to plant the seed of all blocks of corn that have the same rate of growth fully five weeks apart, to make sure of freedom from mixing. The later-planted corn has better conditions, as a rule, and reaches the tassel stage much quicker than the same variety of corn planted earlier and in a cooler soil with shorter days. The mixed nature of the grains resulting from the first generation is shown in the set of six ears in the upper left-hand corner of Plate II. The ear upon the right of the six has much of the shape and zigzag arrangement of the grains characteristic of the "Banana."

Alongside of the above-mentioned block, and planted three weeks later, was the cross of "Mexican" upon "Striped Evergreen" ($\frac{99}{27}$). The time between the flowering of this cross and the one previously mentioned was not satisfactory, and the work of detasseling was needed to prevent mixing between the two blocks. There is quite a difference between these two crosses, both in plant and ear. The first produces a tall plant with narrow, erect foliage, while the second has long, broad, drooping leaves upon stout stalks. The differences between the ears are shown in the upper row in Plate II., the six to the right of the middle being the "Mexican-Striped Evergreen" cross. About half of the ears were a mixture of black and white grains—three-quarters black to one-quarter white—while the others were with both the dark and light grains marked, upon the embryo side in particular, with the



red stripes characteristic of the mother plant. One ear had all the grains of a dark red, but showing by darker color the proportion of mixture with "Mexican" blood of the other ears.

The "Striped Evergreen" has the peculiarity of "throwing red ears," and this tendency was still active even in the above cross. The block was not prolific, but it remains to be seen what this cross can do under favorable conditions for growth.

The "Mexican-Garwood" ($\frac{99}{94}$) block was planted with dark grains from ears of a kind of corn secured from Mr. Gardner, of this State, who has practiced selection with it for a number of years, until it is a fine, uniform strain, approaching the "Evergreen" group of sweet corns. The plants were satisfactory in size and showed much vigor under the very trying conditions for growth. A set of six ears is shown in the lower left-hand corner of Plate II. They were larger in diameter than any other of the four crosses under consideration, and average twelve rows, instead of eight, as in the "Mexican" parent. The white grains are practically one-quarter of the whole number.

The last of the set to be mentioned, because its list or record number is higher than any of the others, is the "Mexican-Malakhov" ($\frac{99}{96}$). The stalks were slender and medium size, due to the smallness of the mother in the cross, and, like it, there was the desirable earliness. The ears, shown in a set of six at the lower right-hand corner, are fairly long and slender, and, of course, eight-rowed, as is the case with both parents. There is promise of getting in this cross a fairly prolific and early sweet corn of superior quality.

By planting the white grains from each one of these crosses, and with a few years of selection, it seems probable that four sorts of white sweet corn may be secured, some of which may prove of merit. In the same manner, by choosing the dark grains of each cross and eliminating the white grains, as they appear in decreasing numbers from year to year and selecting for desirable form of ear, another set of dark sweet corns may be secured, differing widely in some instances from the original "Black Mexican." Thus from the "Malakhov" cross great gain in earliness might be expected, while with the "Garwood" a finer, thicker, longer-grained ear might be secured, with nearly the same lateness as the male parent.

The "Malakhov" Sweet Corn.

The "Malakhov" sweet corn, previously considered in this report and for last year, through the courtesy of Professor N. E. Hansen, horticulturist of the South Dakota Experiment Station, and Professor W. W. Tracy, of the United States Department of Agriculture, was distributed to eighty-four growers, many of whom have reported favorably upon its earliness and sweetness. In the Gardens it was so early that the dry weather, which seriously harmed later sorts, did not materially affect it. By the 10th of July the ears were old enough for the table, and, while small, the quality was good. Some ears were allowed to ripen, and grains from these planted late in July gave a crop, ears of which were ready for cooking upon the 20th of October. The fact that two crops were grown in a single season is sufficient evidence that the "Malakhov" has the merit of earliness. That it is not profitable for commercial purposes seems equally true, and for this reason it has been crossed with more prolific sorts, which are medium early in order to increase the yield, at a possible loss of some of the earliness. Seed of this cross, of which there are a few quarts, is ready for distribution.

Cross of "Black Mexican" upon "Golden Bantam."

A block of twenty hills was planted with dark grains upon an ear of "Golden Bantam" (34), and were evidently the color-marking of the "Black Mexican" (99), the cross being expressed by the fraction $^{99}/_{34}$. The soil and season were very unfavorable and only a few ears were secured. These give the following result in number of black and yellow grains:

Ear No.	Dark Grains.	Yellow Grains.	Mixed.
1	128	46	9
2	130	38	5
3	149	46	4
4	95	22	2
5	85	27	0
6	81	35	2
7	50	21	1
Total	718	235	23
Theoretical	732	244	..

This shows that the black is dominant over the yellow in the ratio that closely agrees with the theoretical numbers that one obtains under Mendel's law.

The mixed grains, while few, are interesting. Some of them are without any color ("white"), while others are mottled black and yellow, and a few are pale lead color. An occasional grain has the dark color only upon one edge or flat side, as if the black and yellow pigments had not been thoroughly mixed together.

Notes upon "Ruby" Sweet Corn.

In 1904 the "Ruby" was grown as No. 76 in the list of sweet corns, and the record shows that its yield was poor, only four fair-sized ears being obtained, averaging four and one-half inches in length. It is one of the late kinds, and, as the name suggests, has the cob and husks of a rich, reddish purple. Upon one of the ears were four yellow flint grains, and these were planted by themselves, far from any other sweet corn. Soon after the plants were up it was noticeable that two of them were red in stem and midrib of leaf, while the other two had the green color throughout common to ordinary corn.

The only yellow flint corn grown in the set the previous year was the "Bryant." It was No. 7, and therefore 180 feet distant from the "Ruby," and it is assumed that the grains planted in isolation this season were a cross of the "Bryant" upon "Ruby."

The "Bryant" is "a small, eight-rowed, early yellow flint," as the record runs, and is therefore a sharp contrast with the "Ruby," with white, wrinkled grains—a true sweet corn—"easily distinguished by its deep purple husks, sheaths and cob."

A count of the grains upon a small ear from a stalk of the "Ruby" type of plant showed 44 white grains and 148 yellow kernels. According to the Mendel principle of heredity, the theoretical number of white grains is 48 and of yellow ones 144.

A week later (September 2d) an ear was taken from the other "Ruby" plant, which plant was larger—fully seven feet tall—and, like the former, red throughout, including tassel and silk, excepting only the main portions of the leaf blades, which were of nearly the usual shade of green. This second ear was seven inches long, eighteen-rowed and well filled out.

The following is the count of grains according to the color and texture:

Row.	Yellow Flint.	Yellow Sweet.	White Flint.	White Sweet.
1	11	5	3	1
2	13	5	2	1
3	18	3	2	1
4	12	5	4	0
5	12	4	3	0
6	12	3	2	1
7	5	4	5	1
8	15	4	2	1
9	20	2	2	2
10	19	2	2	2
11	15	5	2	2
12	12	7	1	4
13	19	5	4	1
14	14	5	3	2
15	18	4	3	0
16	13	4	7	2
Totals	228	62	44	21

Total yellow 290. Total flints 272. Total sweets 83.

The above calculation is based upon the idea, under the Mendelian principle, that both yellow color and flinty texture are dominant characters over white and soft qualities, respectively, and the actual count is as near as might be expected to accord with the assumption, in view of the modifying circumstances. The ear showed twenty-two dark grains in addition to those that have been classified in the above table, and these were due to the effect of a dwarf purple popcorn that was grown in the vicinity of the "Ruby" without the expectation that the flowering season of the two sorts would in the least overlap. All of the dark grains are of the flint type, as expected, and a majority of them show a mixture with the yellow.

Color of the Cob.

The color of the cob is perhaps a character that obeys the Mendelian rule in breeding. Thus a block of twenty hills of "Black Mexican" upon "Early Windsor," the latter having a reddish or "rusty" cob, gave thirty-three ears, ten of which were with white cobs and twenty-three with a color like the mother of the cross. In another block was grown a cross of "Perry's Hybrid" upon "Ne Plus Ultra," the former having the reddish cob quite frequently, and as a result there were seventeen "rusty" and twenty-three white cobs. Failure of a nearer approach to the theoretical ratio of three to one (the colored cob naturally assumed to be the dominant) may be found in the fact

that the "Perry's Hybrid" does not have the character of reddish cob in all instances. This mixture of strongly contrasting cobs in itself suggests that the character is one that does not blend, but instead remains in full force, even in a cross-breed, in which one of the characters of color of the cob has not been removed by selection.

Crossing of Sweet Corn in 1905.

Upon a strip of the new ground fifty-nine varieties of sweet corn were grown, under the following conditions: Lengthwise of the strip, thirty-three feet wide, row No. 3 was planted with "Black" popcorn; row No. 6 with "Adams," and row No. 9 with "Golden Bantam."

From the hundred and more numbers of the varieties of sweet corn only those were selected that are recorded as "white"—that is, all those that are colored and those of a flint or dent nature, whole or in part, were excluded, which resulted in the list being limited to the following:

1. "Acme," Fmr.
5. "Asylum," Hlm.
6. "Banana," Fqr.
9. "Early Maine," Chl.
*11. "Champion," Hen.
*12. "Chicago Market," Cur.
*14. "Columbus Market," Liv.
15. "Cory," Jerr.
*19. "Country Gentleman," Exp.
*20. "Crosby Early," Drr.
21. "Crosby Medium," Munson.
*22. "Don," W. & D.
*23. "Egyptian," Fqr.
*24. "Eight-Rowed," Thr.
25. "Ferry's Early Evergreen," Fer.
*28. "White Evergreen," Bur.
*29. "Essex Early," Ggy.
30. "Eastern Early," Chl.
*31. "First in Market," Ham.
*33. "Early Fordhook," Bur.
*39. "Henderson," Hlm.
*41. "Hiawatha," Wd.
**42. "Hickox Improved," Liv.
*43. "Honey Dew," Chl.
**48. "Lvs. Evergreen," Liv.
*51. "Marblehead," Ggy.
54. "Oakview Market," Fqr.
*55. "Maule's XX," Mau.
57. "Metropolitan," May.
58. "Minnesota," Bru.
*61. "Moore's Concord," Thr.
*62. "Ne Plus Ultra," Thr.
*63. "Nonesuch," Hlm.
64. "Old Colony," Fmr.
*65. "Peep O'Day," N. K.
*67. "Pharaoh's Dream," Iow.
69. "Potter's Excelsior," Drr.
*70. "Premier," Brk.
*73. "Premo," Hlm.
**75. "Roslyn Hybrid," Drr.
*76. "Ruby," Bur.
*77. "Russell's Prolific," Vk.
78. "Shakers' Early," Hlm.
80. "Silver Coin," Liv.
*81. "Stablers' Early," Bur.
83. "Stowell's Evergreen," Drr.
86. "Early Sunrise," Iow.
88. "Triumph," Drr.
89. "Early Windsor," May.
90. "Zigzag," Hlm.
91. "Zigzag," Brk.
**94. "Garwood," Gardner.
95. "Malakhov," Hansen.
98. "White Mexican," Sox.
*101. "Giant," Mau.
*102. "Howling Mob," Bur.
103. "Mammoth Early," Ggy.
*104. "Oregon Evergreen," J. & S.
*105. "Top-Notch," Hlm.

The last five are varieties that had not been grown before at the Gardens, and under the unfavorable circumstances it is not fair to either praise or condemn them. All but one received a single star for product at harvest time; none of the ears were picked green and tested as to table quality. They were generally promising, and it is with regret that they could not have been compared with the old standard varieties in every particular.

A row of each ran across the strip and consisted of eight hills, the series being broken in each case by a hill of "Black Pop," "Adams" and "Golden Bantam," respectively. The plan was to breed upon the white sweet sorts the three last-named distinct varieties, thus getting a cross of each of them, each mixed grain to be marked by dark flint, light flint and yellow sweet, respectively.

The season was unusually dry during the period of growth of the early varieties and the crop from these was unusually small, several of which being practically a failure. Of the three "breeders," so called, both the "Black Pop" and the "Golden Bantam" were for the same reason a small crop, and the "Adams," while better, gave but a poor yield. Crosses were, however, obtained with all the varieties that gave any sizeable ears. The white sweet sorts that did the best under the very trying circumstances are marked with a star in the list under test. Four of special merit are double-starred.

In the breeder row of "Black Pop" containing fifty-nine hills were two stalks larger and later than the others that produced an ear each quite different from the regular type. Instead of a slender ear with the grains uniformly black was one over seven inches long and nearly two thick, with sixteen rows of vari-colored grains, about one quarter of which were white and the remaining three-fourths nearly evenly divided between yellow and a mixture of dark and dark yellow. It may be that the grain producing this plant was a mixture of white and black, the black obscuring the white blood, or else it would have been observed in the shelling of the seed from the black ear at time of planting. If it were a mixture of black and yellow it might have passed unnoticed, but then it is not easy to account for the quarter of white grains. If it were a white grain (flint, of course) the large amount of black grains is easily accounted for, but not so the equal number of yellow grains, because the "Golden Bantam" was twenty-one feet away and it did not impress itself to a like extent upon any other ears that distance away. But most difficult, under this last

suppositior, is the explanation of the large number of grains that evidently show a mixture of the black and yellow.

In the row of "Adams," which is a white dent, the marking of the "Black Pop" was often strongly in evidence, a fact to be expected. These grains were usually finely mottled, giving them a pink or purplish shade, but in shape they were that of the broad-topped dent of the mother plant.

It is interesting to note that some ears showed several wrinkled grains of the ordinary sweet type, a fact not easy to account for unless it be the result of a previous cross upon it of sweet corn, the seed not showing the fact. If a grain of genuine sweet corn had been planted it needed to escape the trained eye of the experimenter, and then the number of sweet grains in the offspring might naturally be greater than that found. Similar observations were made last year.

Occasionally a yellow-colored grain, always flint, was found upon the "Adams" ears, suggesting the effect of the "Golden Bantam."

"Voorhees" Corn from Various Regions.

As a result of the distribution of "Voorhees" corn to the Experiment Stations, the following representative list was made up for comparative tests the present season:

No. 1. Vermont. Professor W. Stuart, Burlington, Vt.
" 2. Connecticut. Professor F. A. Gulley, Storrs, Conn.
" 3. New Jersey. Mr. S. A. Gardner, Maplewood, N. J.
" 4. Pennsylvania. Professor Geo. C. Butz, State College, Pa.
" 5. Virginia. Professor H. L. Price, Blacksburg, Va.
" 6. North Carolina. Professor W. F. Massey, Raleigh, N. C.
" 7. Louisiana. Professor F. H. Burnette, Baton Rouge, La.
" 8. Illinois. Professor J. C. Blair, Urbana, Ill.
" 9. Iowa. J. A. Kelsey, Dunlap, Ia.
" 10. Kansas. Professor Albert Dickens, Manhattan, Kan.
" 11. Colorado. Professor W. Paddock, Ft. Collins, Col.
" 12. Nevada. Professor P. B. Kennedy, Reno, Nev.
" 13. Washington. B. E. Musser, Bellingham, Wash.
" 14. Hawaii. Professor J. T. Higgins, Honolulu, H. I.

There were two rows of each lot, the rows running across the thirty-three-foot strip; that is, the area covered was thirty-three by eighty-four feet, the hills being three feet apart both ways.

The series began with two rows planted with Vermont-grown seed and ended with that from Hawaii. All came up fairly well excepting

the sample from North Carolina, and these two rows were replanted with grains from another ear from the same lot, and this grew and made the largest corn, by a foot and a half, in the whole block. This is mentioned to show how unfavorable was the season here for sweet corn planted, as this was, early in May. The test amounted to but little, for the corn did not grow on account of the prolonged drought in May and June. After the rains came it was too late, as the short stalks had set their ears, and the crop was a partial failure. In view of the very late moist autumn, the results perhaps would have been reached by a late planting, as the only two rows with full-sized stalks and ears were the ones in the replanted rows for North Carolina.

Upon June 2d the record shows that the most promising rows were New Jersey, Virginia, Illinois, and Iowa, followed by Connecticut. Kansas, Nevada, Washington, Hawaii, Vermont and Colorado were about equally poor, and, as before stated, North Carolina was nearly a failure. It was noted at this time that the color of the young foliage was somewhat different in the plants from the far-western-grown seed. There was a large maple tree at the end of the strip and nearest to this set of samples, which may have accounted for this appearance, as it did without doubt for some of the dwarfishness of the plants later in the season.

In the ears harvested there was nothing noted to indicate any change possibly due to the different conditions under which the seed had been grown. The experiment teaches emphatically the difficulties that lie in the path of one who would make tests of climatic influence upon future offspring among such plastic annual plants as corn.

It may be said that the ears were generally entirely red, with the single striking exception of those from the Connecticut rows, which were much mixed with white.

A LIST OF THE POPCORNS GROWN IN 1905.

The following is a list of the commercial varieties of popcorn grown upon the home grounds the past season. The soil devoted to this purpose was not well adapted to the crop, and the season being unfavorable, the results as to yield were not satisfactory. Also, one end of the plot was somewhat overshadowed by a maple tree, and this doubtless prevented the rows from No. 26 to No. 31 from being comparable with the others. The last five kinds, Nos. 31 to 36, upon account of their color and other peculiarities, were grown upon separate plots, widely

separated from each other and the main portion of the popcorn area. In short, Nos. 1 to 31 were grown in a strip with a row of eleven hills across it to each number and in the order given in the accompanying plate. The tree stood at the end and twenty feet away from the side of row 31.

There was a difference in the habits of growth among the various numbers. The list follows, with source of seed and some remarks appended to each:

No. 106. "*Red Beauty.*" Buck. It was the earliest of all; a very small red rice that gave but a few ears.

" 107. "*Red Rice.*" This seed was received from Brazil through the U. S. Department of Agriculture. The plants were very stout and ten feet in height and so late that no mature seed was secured. The ear shown in the group was gathered upon October 10th. It is evidently too slow in habit for the New Jersey climate. A red color is present in all parts of the plant.

" 108. "*Red Rice.*" A. D. Co. This is a medium small and early corn with ears of greater diameter than No. 106. The grains are broad and approach the pearl in shape.

" 109. "*Red Rice.*" U. S. D. A. This is similar to the last, somewhat larger plants and more productive. The ears are more slender and the grains of a lighter red. This and all the other red rice samples produced white ears, but in no instance was there any mixing of these two colors upon the same ear.

" 110. "*Bronze.*" Ggy. This is a very small and early corn with slender stalks that quickly fall to the ground. The ears were small and the grains in many rows had the very sharp tip strongly developed.

" 111. "*Bronze.*" U. S. D. A. This seemed the same as the last in all respects. The bronze and the red rice are much alike and both frequently produce white ears. The "bronze" color is midway between the red and yellow.

" 112. "*Rice.*" A. D. Co. This is a medium tall sort and quite early. The ears were stout and short with the grains closely set and not sharp-tipped.

" 113. "*Yellow Rice.*" U. S. D. A. Brazil. This was one of the very tall sorts, the plants being from eleven to thirteen feet high and were only coming into tassel on the first of October. The plants were very leafy and gave evidence of being of value as a forage crop. Standing upon tiptoe, the writer was able to reach only to the middle ear with the tallest specimens. The sample shows only the slender nature of the cob and the forming grains.

" 114. "*Queen's Golden.*" A. D. Co. This is a sort with very large plant and late in maturing its ears, which are handsome in shape and with bright yellow pearl grains.

" 115. "*Queen's Golden.*" Field. The plants were large and ripened their ears about October 1st. The color of the grains is the same as for No. 114, but their shape and arrangement upon the cob are different. The engraving shows these peculiarities.

No. 116. "*Queen's Golden.*" J. & S. This was somewhat smaller than the last and the ear more tapering, with the grains of a darker yellow. A very handsome corn and presumably eastern grown, which may account for the smaller size of plant and earlier maturity.

" 117. "*Queen's Golden.*" Vau. As to plant this was the same as the last, but the ears are sharper pointed and the grains much larger, with a pointed end, suggesting the "rice" form. Many grains failed to mature and the ears were all with irregular rows.

" 118. "*Queen's Golden.*" Y. & H. In plant this was nearly like the last two, but the seed did not give a good stand. The ears are long and slender, with the grains smaller than any other of the "Queen's Golden" group and in twisted rows upon the cob.

" 119. "*Amber Pearl.*" Hend. This gave a set of stout plants of medium size and productiveness. The ears are long and slender, rows straight and grains flat topped and rectangular and in color approaching amber.

" 120. "*Yellow.*" U. S. D. A. India. This is a stout, medium small and medium early corn, with the husks very stiff upon the short, pointed ears. The straw-colored grains are large, of the pearl type and somewhat irregularly disposed on the cob. It is different from any other in the list.

" 121. "*Eight-Rowed.*" A. D. Co. This is a small and early corn with the ears very slender and usually eight-rowed. The one in the picture, however, is ten-rowed. The grains are large and rectangular and of the plain "white" color.

" 122. "*White Pearl.*" Brk. This is a tall, late-maturing sort, averaging nine feet high and with the ears still green upon the first of October. The ears are cylindrical and fourteen to sixteen-rowed, with the grains small and of good length.

" 123. "*White Pearl.*" A. D. Co. This is practically the same as the last, but with us it was far less productive and the ears much smaller.

" 124. "*White Pearl.*" U. S. D. A. This does not differ from the last two and gave one of the most prolific rows of shapely ears.

" 125. "*Mapledale Prolific.*" J. & S. This is medium early sort, with slender stalks. The ears are rather stout, with a tinge of rose in the small shining grains.

" 126. "*Mapledale Prolific.*" Vau. This is quite like the last with the slender stalks not able to remain upright after maturity. The ears are stout and the rows many of small, hard, white grains.

" 127. "*Silver Lace.*" Burp. This is nearly the same as the last in form of plant, but the ears are smaller, more tapering, and the husks are remarkably soft when mature.

" 128. "*Rice.*" U. S. D. A. Brazil. This sort was one of the largest of the list, with very tall, leafy plants, just coming into silk upon October 1st. The immature ear, gathered upon the tenth of that month, is shown in Plate III.

" 129. "*Rice.*" A. D. Co. This is a medium-sized sort, red throughout, that stood up well. The ears medium early, and are not large, with the large, sharp-pointed, "white" grains, often irregularly placed.

" 130. "*Rice.*" A. D. Co. (No. 2). This is somewhat larger and later than the last, with the grains quite uniformly in rows.

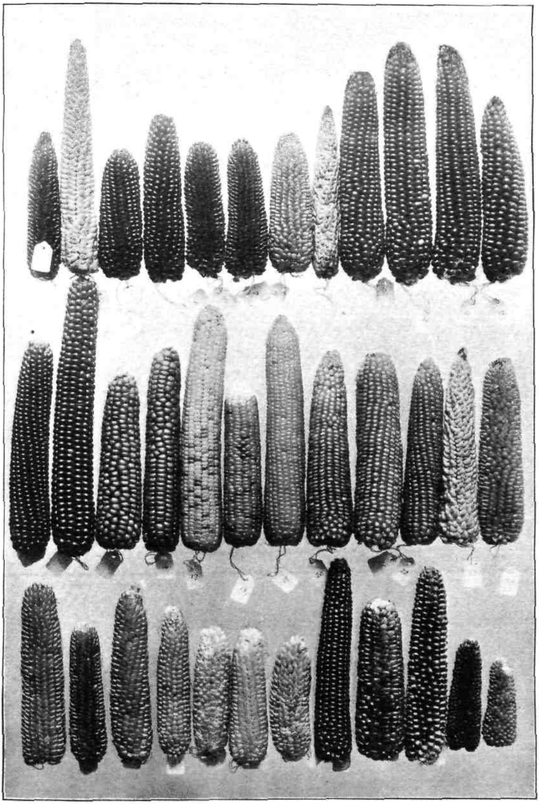


PLATE III.

Sample ears of thirty-six lots of Popcorn grown upon the Experiment Grounds during 1905.

No. 131. "*Rice.*" A. D. Co. (No. 3). This is a small sort, green throughout, and with the ears short.

" 132. "*Rice.*" A. D. Co. (No. 4). This is a medium-sized sort, with red color throughout, and the ears with the grains somewhat as in No. 129.

" 133. "*Rice.*" J. & S. This is nearly the same as the last, but did not yield as well. The grains are less pointed.

" 134. "*Rice.*" Vau. This is the same as the last.

" 135. "*Rice.*" Y. & H. This is the same as the last two.

" 136. "*Snowball.*" Buck. Seems to be the same as the last three. All of these last were too shaded for good results.

" 137. "*Black.*" A. D. Co. This is a characteristic, small, early variety, with slender, usually curved ears, bearing large, dark grains, varying from lead-colored to nearly black.

" 138. "*Striped.*" Buck. This is a strong-growing sort, maturing medium late and bearing short, stout ears, with the large rice grains more or less striped with amber.

" 139. "*Tattooed Yankee.*" Chl. This is a tall, slender-stalked sort that falls badly. The ears are long, bearing large, much-pointed grains that are mixed yellow and black.

" 140. "*Dwarf Purple.*" U. S. D. A. This is a quick-growing sort, making a height of three or four feet and producing small, tapering ears, with the pointed grains of an amethyst color and arranged irregularly.

" 141. "*Dwarf Yellow.*" U. S. D. A. This is a most decided dwarf, the plants not being over two feet high and the ears as many inches long. The pointed grains are of a delicate straw yellow and of the zigzag type in their arrangement.

This list of thirty-six numbers, samples of which are shown in Plate III., may be divided, first, into the standard and dwarf, and the former into the rice and the pearl. Of the rice type there are the white, red, bronze, striped and tattooed. The pearls group themselves into the white, yellow and black, and the white pearls may be divided again by the separation of the sort known as the eight-rowed, because of the characteristic which its name bears.

It is too early in the study of these plantings to determine the number of well-defined varieties. The "Red Rice" and the "Bronze" are quite alike, save in the less developed red in the latter. Both have the peculiarity of having many white ears, and these are not distinguishable in the "red" and "bronze" rows. The "Amber Pearl" may have peculiarities which definitely separate it from the "Queen's Golden." The "Mapledale Prolific," while showing differences from the "White Pearl," are, as seen in the present test, no greater than among the several rows of the "pearls" themselves. In the same way, the "Silver Lace" does not appear to be distinct from the "White Pearl." The

"Snowball" is apparently a white rice. The "Black" is unmistakable, but the "Striped" and "Tattooed Yankee" need to be studied to determine whether their peculiarities are not those of mixing rather than of a fixed variety. For example, opportunity was taken to grow the latter in two isolated blocks, the one planted with only the yellow grains and the other with black kernels, and as a result of the first season the yellow seed produced fifty ears, a full half of which were entirely yellow, and the remaining half showed much less of the dark grains than the block planted with the dark grains only. It looks as if this sort might, by selection, be resolved into its yellow and dark constituents, which might be old varieties. One of these might be a yellow rice, a form that it is noted is not present in the above list, and I do not recall having met with it.

Plate IV. shows a selection of perhaps the most popular sorts of popcorn, and along with the seven ears are given sections across the ear, a watch-glass containing shelled grains and a few samples of the popped corn. Beginning at the left hand, the "Queen's Golden" shows a long, tapering ear with rather large grains, which, when popped, show some of the yellow throughout the whole grains, giving a creamy appearance which is pleasing and quite different from any other of the seven sorts. This attractive, rich color is not shown in the popped grains which are placed directly above the ear. The "Black" is one of the best to pop, and yields large grains with the flesh of almost chalky white, in striking contrast to the fragments of the hull. The heat seems to reduce the dark color of this exterior to a dull brown. Were the "Black" a more prolific sort there is reason for its being quite popular. The "Speckled Pearl" here shown, but not grown in the regular series because of its dark grains, seems to be one of the popular sorts found generally in our local markets. The ears, in shape and general appearance of the grain, are quite like the "White Pearl." It may be earlier, and this would add to its popularity. By selection, ears with cherry-colored pearl grains might be secured that would be very handsome, in addition to other good qualities. The "Speckled" produces a superior popped product.

The "Eight-Rowed" has proved to be, after repeated trials, one of the very best varieties for popping, and its large grains yield a product that takes on many fantastic shapes, due perhaps to the unusual width of the kernels. In the "White Pearl" we have perhaps the most widely-used corn, the "White Rice" being a good second in this regard. The

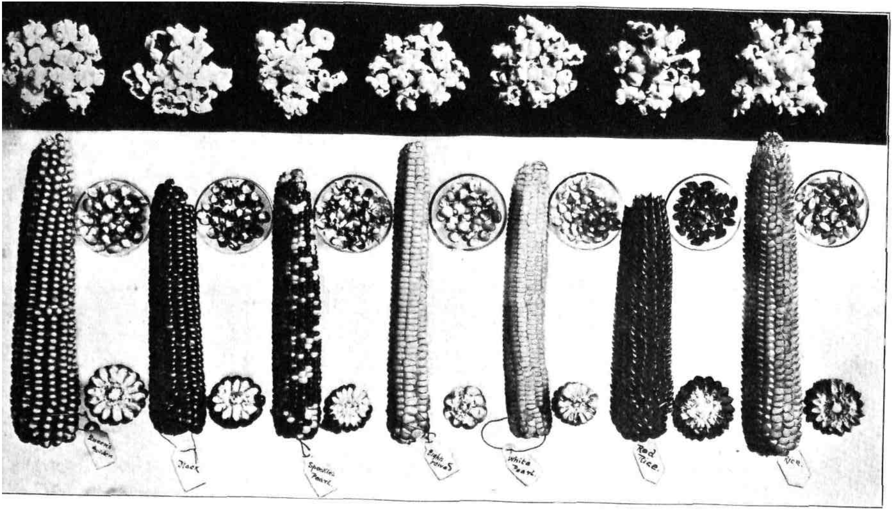


PLATE IV.

Seven kinds of Popcorn, showing (1) ear, (2) section of ear and shelled corn, and (3) the popped grains of each sort.

popped grains of the two are scarcely distinguishable unless one looks carefully for the pointed tip which, when the grain is fully exploded, is lost from sight. The limited experience of a single season is not sufficient to judgeaof the yield in the eastern climate, but both are productive. The "Red Rice," while very attractive as ears in the market, is objectionable in that the popped grains are strongly marked with the hull, the red color of which does not disappear under the influence of the fire while being popped. Again, so many of the ears are white that a crop is a mixed one. Quite unlike the "Speckled," the two kinds of grains are never found in our experience upon the same ear.

In Plate IV. the upper portion, with black background, shows piles of popped corn, each representing the kind that is given just below in the ear and shelled, but the cream color of the "Queen's Golden" and other details quickly noted in the specimens themselves are lost from sight.

EXPERIMENTS WITH TOMATOES.

Old Varieties Grown the Present Season.

The following sorts of tomatoes were grown the present year from seed obtained in the open market, the source of each variety being indicated by the official contraction of the name of the seedhouse furnishing it. These were grown chiefly for the sake of comparison with the crosses that had been secured the previous year from plants grown from the same packets, and therefore all of the seeds in this list were purchased in the spring of 1904. It may be stated in passing that, with one or two exceptions, the seeds produced plants of normal vigor. A second reason for the growing of the old set was that a number of much-desired crosses might be made the present season. Time was not taken in making any study of the comparative value of the varieties. They, however, did not vary essentially from the record of the previous year, excepting in that the yield was materially larger, due to the season. No frost came this year to cut the vines until October 29th, which was nearly a month later than during the previous season.

1. "Acme," Btl.
2. "Acme," Liv.
4. "Arcadia," Jer.
6. "Atlantic Prize," Btl.
8. "Beauty," Btl.
10. "Belmont," Brk.
11. "Bermuda," Lan.
12. "Best of All," Drr.
13. "Brandywine," J. & S.
14. "Bright and Early," Vk.
15. "Brinton's Best," J. & S.
17. "Buckeye State," Fer.
21. "Climbing," Chl.
26. "Crimson Cushion," Hen.
27. "Crimson Whirlwind," Sal.
28. "Cumberland," J. & S.
29. "Dominion Day," Bru.
30. "Democrat," Thr.
32. "Duke of York," Rolfs.
33. "Earliana," Bru.
34. "Earliana," Fer.
36. "Earliana," Hulsart.
37. "Earliana," Rolfs.
42. "Early Ruby," Liv.
44. "Enormous," Hrs.
48. "Favorite," Liv., Btl.
49. "Favorite," Trucker, Bur.
53. "Fortune," J. & S.
54. "Freedom," Hen.
55. "Frogmore," Drr.
56. "Giant," Evr.
57. "Giant Climbing," Evr.
58. "Grandus," Liv.
60. "Honor Bright," Brk.
62. "Ignotum," Hlm.
63. "Imperial," Drr.
64. "King Humbert," Drr.
65. "King of the Earlies," Rolfs.
66. "Jewel," Bur.
67. "La Crosse Seedling," Sal.
69. "Liberty Bell," J. & S.
71. "Lorillard," Elt.
72. "Magnificent," Mau.
75. "Magnus," Ggy.
77. "Marvel," Drr.
81. "Matchless," Rolfs.
83. "Mayflower," Drr.
84. "Melrose," Hlm.
85. "Michigan," Fer.
87. "Minnesota," Ggy.
90. "Mikado," Evr.
93. "New Jersey," Thr.
94. "Nolte's Earliest," Fer.
96. "Novelty," Thr.
98. "Paragon," Liv.
99. "Perfection," Btl.
101. "Picture Rock," Chi.
102. "Pink," Hulsart.
103. "Ponderosa," Hen.
104. "Potato Leaf," Liv.
107. "Prizetaker," Hlm.
109. "Princess," Liv.
110. "Quicksure," Iow.
115. "Royal Red," Btl.
118. "Shipper's Choice," Ham.
121. "Stone," Btl.
122. "Stone," Hulsart.
123. "Stone," Liv.
124. "Stone," Rolfs.
125. "Success," Bur.
128. "Sutton's Best of All," Thr.
135. "*Tree, Giant,*" *Sal.*
136. "Trophy," Drr.
137. "T. T. T.," Lan.
139. "Volunteer," Liv.
141. "Wonder," Elt.
143. "1903," Thr.
144. "Golden Queen," Btl.
145. "Golden Queen," Liv.
147. "Lemon Blush," Thr.
148. "Yellow Prince," Liv.
149. "Aristocrat," Farm.
150. "Aristocrat," (?) Hlm.
151. "Aristocrat," Liv.
152. "Aristocrat," Vau.
153. "Champion," Btl.
154. "Champion," Brk.
156. "Champion Scarlet," Brk.
158. "Dandy Dwarf," Liv.
159. "Extra Early Tree," May.
161. "Kansas Standard," Btl.
169. "Dwarf Stone," Hulsart.
170. "Dwarf Stone," Liv.
172. "Gold Ball," Liv.
173. "Golden Fig," Chi.
174. "Golden Nugget," Iow.
175. "Ivory Ball," Lan.
176. "Red Cherry," Thr.
177. "Red Currant," Thr.
178. "Red Peach," Thr.
179. "Red Pear," Thr.
180. "Red Plum," Thr.
181. "Sumatra Fig," Sal.
183. "Yellow Cherry," Thr.
185. "Yellow Pear," Thr.
186. "Yellow Peach," Liv.
187. "Yellow Plum," Thr.

Notes upon "Magnus-Ponderosa" Crosses.

A block of thirty plants of the cross of "Magnus" (75) upon "Ponderosa" (103) were grown. This was the second generation of the mingling of these two varieties, both strong in their peculiarities. The "Magnus" is a standard, coarse-leaved ("potato leaf") sort, with remarkable vigor, producing a tall plant and fruit of medium size and quite uniformly deep apple-shaped. The wall is thick and the seed cavities are from five to eight, with usually a central core unbroken with seed cells. The "Ponderosa," one of the very popular tomatoes, is a very vigorous plant of the fine-leaved type and produces fruits often of unusual size, but sometimes objectionable because of their flatness and irregularity of outline. The center is much broken up by the many seed cavities, in which the seeds are comparatively few in number. The two varieties, it is seen, differ in character of foliage and form and internal structure of the fruit. They both agree in the color, which is the so-called "pink" or "purple."

During last winter plants of both these sorts and the cross between them were grown in the greenhouse, and even under the unfavorable conditions of lack of abundant sunlight, due to high neighboring buildings, they showed that vigor and fruitfulness were their strong qualities.

In the field the plants were of the second generation and showed the two types of foliage, there being twenty-one of the fine-leaved and nine of the coarse-leaved kind. This accords somewhat closely with what might be expected under Mendel's law where the fine-leaved type is assumed as dominant and the coarse-leaved the recessive character.

The fruits have all been of the "pink" color, and therefore true to both parents, as might be expected. There has been quite a range in size and shape among the various plants. Greater uniformity prevailed in the coarse-leaved plants, and this is as if the "Magnus" blood was dominant, but the fruits were not the same as those of "Magnus" grown elsewhere for comparison. The fruits of the "Magnus" type were larger and the seed cavities were more numerous than the true "Magnus."

In other words, the size and shape of the fruit are altered in the recessive plants of this cross.

The greatest improvement is seen in the fine-leaved plants, where, also, the largest amount of variation in fruit is seen. Some of these plants produced largely of apple-shaped fruits—for example, near that of a good "Baldwin." Sixteen such ripe fruits were taken from a single plant at one time, the total weight of which was six and a quarter pounds. Other plants produced fruits in smaller numbers but of much larger size, showing more of the "Ponderosa" than the "Magnus" qualities, but less irregular and flat than the pure "Ponderosa." It is of those plants that yield the apple-shaped fruits, all of them sufficiently large, that most is to be hoped for in this cross, and from such plants a quantity of seed has been secured. The aim has been to obtain a prolific plant, the pink fruits being large and deep, with thick wall and a juicy core, somewhat broken by small seed cavities, and with the number of seeds comparatively few.

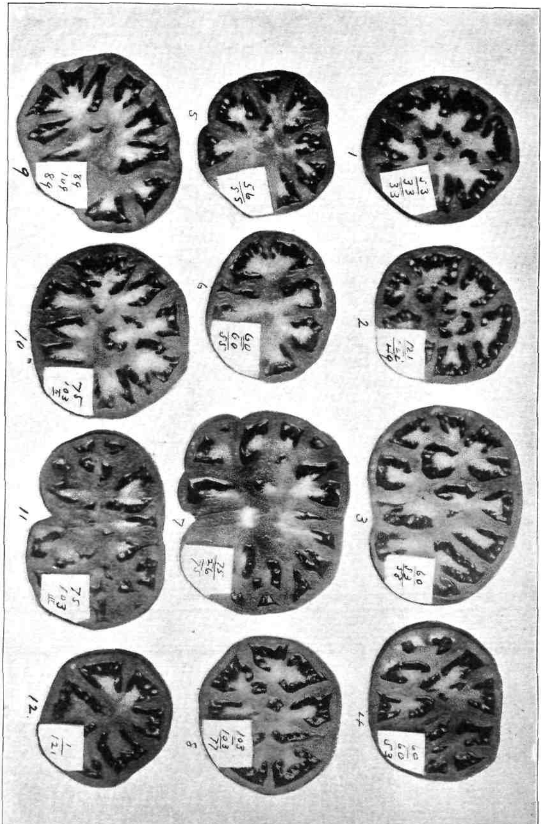
A slice-view of a fruit of the "Magnus-Ponderosa" cross is shown at 10, in Plate V., and one of a third generation at 11. Ten plants of this last generation were grown in a separate block from the above, and were full of vigor and fruitfulness.

Notes upon "Champion-Magnus" Crosses.

Because of the dwarf habit of the "Champion," and the fact that it has the fine-leaf type of foliage, a cross of it with the "Magnus," a standard, coarse-leaved variety, admitted of a wide range in the offspring. From a single fruit of such a cross—"Magnus" upon "Dwarf Champion"—eighty-five plants were obtained and set in a block in the Gardens. From an early stage in the growth of the seedlings it was seen that at least four types were in evidence, namely, the standards in both coarse and fine leaves, and dwarfs, likewise, of the two forms of foliage. This distinction was maintained throughout the season, so that side by side grew plants of widely different aspect.

A count of the forms and the number of good-sized fruits for each plant resulted in the following:

Standard, fine-leaved plants,	49	theoretical,	48—	Average fruits per plant,	22
Standard, coarse-leaved "	16	"	16—	" " " "	19
Dwarf, fine-leaved "	13	"	16—	" " " "	15
Dwarf, coarse-leaved "	7	"	5+	" " " "	11



The number of plants on each type conforms somewhat closely to Mendel's law, if it is assumed that standard form of plant and fine-leaved foliage are the dominant characteristics and the dwarf plants and coarse leaves are the recessives. The number of plants is, however, all too small to more than arrive at a suggestion from this single instance.

In the number of marketable fruits per plant it is seen that the standard types outnumber those produced by the dwarfs. This does not decide that the latter are inferior but smaller in yield, as they are also much smaller in size. Double the number of dwarfs can be grown upon a given area, and even then the ground does not become a tangle of vines, as in case of the standards. The fine-leaved dwarfs, set twice as many to a given area, might give a much better return than when the standard, fine-leaved form is grown. The dwarf, coarse-leaved form is handsome, and the plants keep the upright position until the fruit is nearing maturity, when winds and rains cause them to bend bodily to one side.

During a heavy picking the fruits of each of the four types were kept separate and as a result some variation in size was noted, those of the standard, fine-leaved averaging the largest and the dwarf, coarse-leaved the smallest.

During a period when almost daily rains prevailed for a fortnight, the decay seemed to be almost equally distributed among the four types.

As was expected, the fruits were of the pink color, thus resembling that of both parents. There was one evident exception, in which the color was a distinct red, a fact suggesting that a seed had been fertilized with foreign pollen.

The fruits are quite uniformly larger than the "Champion" and close to the somewhat angled form of the "Magnus." In other words, out of this cross, by selection, four types of plant and foliage may be expected, all with practically the same form of fruit, but differing materially in stem and foliage. The coarse-leaved standards are the tallest plants, while the coarse-leaved dwarfs are the smallest. The greatest range in size is met with in the fine-leaved plants.

There was one plant that, while ranked with the fine-leaved standard type, was quite unlike any other in its foliage. The leaves showed a strong tendency to produce long, slender expansions, that were as far from the ordinary tomato foliage upon one side as the coarse-

leaved type is upon the other. Several other plants with this filiform type of tomato foliage were met with among the crosses of the year. They seem of no economic value, but as a mutation attempts will be made to determine the permanence of the above-mentioned character.

Plate VI. shows the four types of foliage found in the "Magnus-Dwarf Champion" cross. At *a* is a tip of a dwarf, fine-leaved plant, at *b* a standard, fine-leaved, at *c* a dwarf, coarse-leaved and at *d* a standard, coarse-leaved plant. The older leaves of the plants show greater differences than their younger ones.

A Study of the Crosses.

The plan was to have the crosses in what may be called families—that is, associated with each cross it was intended to have the following: (1) male parent upon the cross, (2) the cross upon male parent, (3) female parent upon the cross, and (4) the cross upon the female parent. For example, the first cross upon the list is "Arcadia" (4) upon "Acme" 2, expressed in the record books by the fraction $\frac{4}{2}$. The "family" of which this is the head is:

$$\frac{4}{\frac{4}{2}},\ \frac{\frac{4}{2}}{4},\ \frac{2}{\frac{4}{2}},\ \frac{\frac{4}{2}}{2},\ \text{or}\ \frac{\text{m. p.}}{x},\ \frac{x}{\text{m. p}},\ \frac{\text{f p.}}{x},\ \frac{x}{\text{f. p.}}.$$

The double bar in the fraction separates the two members of the second cross; m. p. are the initials for male parent and f. p. for female parent. This gives double reciprocals of the cross with the parents and furnishes a set of four three-quarter "bloods," two of them upon the male and two upon the female side.

Full "families" were obtained in only a few cases, for example, "Arcadia" upon "Acme" $\frac{(4)}{(2)}$; "Ponderosa" upon "Marvel" $\frac{(103)}{(77)}$; "Magnus" upon "Ponderosa" $\frac{(75)}{(103)}$; "Mikado" upon "Princess" $\frac{(89)}{(109)}$; "Stone" upon "South Jersey" $\frac{(123)}{(119)}$; "Dwarf Stone" upon "Dwarf Champion" $\frac{(171)}{(153)}$; "Ignotum" upon "Red Peach" $\frac{(62)}{(178)}$, and "Ignotum" upon "Red Plum" $\frac{(62)}{(180)}$. There were many "families" with only a single member lacking. Attention is first given to the complete sets.

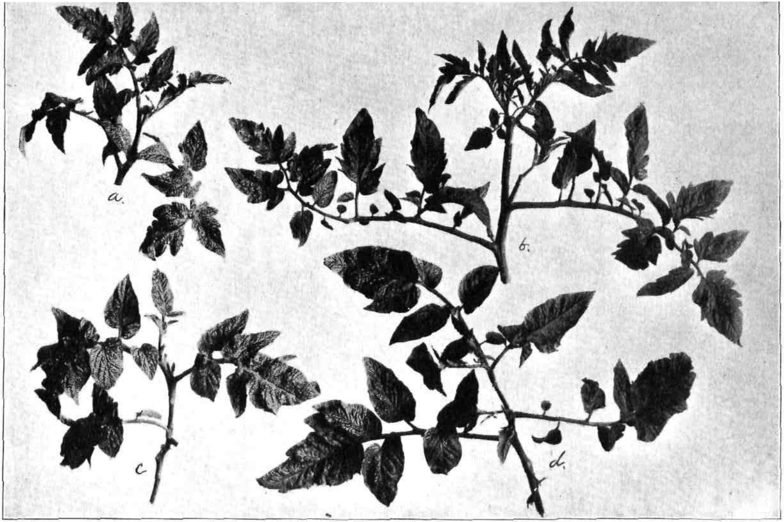


PLATE VI.

The "Arcadia-Acme" Family.

In the matter of popularity the two parents in this group are the extremes, for the "Arcadia" is not mentioned in the Tracy list,* while the "Acme" is exceeded in number of seed-houses handling it by only "Beauty," "Stone," "Dwarf Champion," "Perfection" and "Livingston's Favorite." The "Arcadia" is red-fruited, while the "Acme" is pink or purple. Both are early and the "Arcadia," having a larger fruit than the "Acme," it was the hope to increase the size of the latter and possibly secure some other advantageous characteristics.

The first cross—that is, a half blood—gave an even lot of average plants, three of which produced pink fruits that were comparatively smooth. The other three had red fruits, and these were somewhat flat and irregular. They were all early. The male parent upon the cross gave two types of plants—one like the "Arcadia," with large, flat, irregular fruits, and the other (two plants) like the "Acme," which were smooth and prolific. The row containing the reciprocal of the last did not differ from that essentially. In case of the "Acme" upon the cross, the plants were uniform in size and the fruits also smooth and larger than the "Acme." Four were pink and two red. The red-fruited plants were more productive than those producing the pink fruits. The reciprocal of the last—that is, the cross upon "Acme"—had only three plants, two of which were pink and one red. The fruits were smooth, medium-sized and quite like the last. It remains to be determined whether there is any substantial gain in this series of crosses over the parents.

The "Ponderosa-Marvel" Family.

The "Ponderosa" is a large, standard, fine-leaved variety of tomato plant that has become very popular for its great fruits, from which fact it takes its name, which are of a decidedly irregular shape but of a handsome "pink" color, while the "Marvel" is much less known, and differs in the more nearly smooth, medium-sized red fruits, which mature evenly and somewhat earlier than the "Ponderosa."

* Bulletin U. S. Department of Agriculture, Bureau of Plant Industry. List of American Vegetables for the years 1901 and 1902, by W. W. Tracy, Jr.

There were four plants of the cross in its second generation, all of which were large and bore fruits in abundance of a size and shape quite intermediate between the two parents, excepting that they were all red. The records show that many of the fruits, because of the good depth, were extra fine in shape and did not have much of the irregularity so objectionable in the "Ponderosa." The expression "very fine, smooth" was used in connection with many of the fruits. One plant had an oblong fruit that possessed a remarkably fleshy interior. In the cross of the "Ponderosa" upon the above cross four of the five plants produced red fruits and one "pink," the latter being quite irregular and closely resembled the "Ponderosa." The whole row was very prolific. In the reciprocal of the last—that is, the original cross upon the "Ponderosa"—the plants were of large size, and three bore red and two "pink" fruits, all of which were large and somewhat irregular and flattened. In the three-quarter "Marvel" —that is, this parent upon the original cross—the six large plants all produced fruits that were somewhat of a blend of the red and "pink" of the two parents. The fruits are very large and nearly always smooth. The record shows that forty-six ripe, sound fruits were picked from the six plants at one time, and they filled to the brim a large-sized peach basket. These large fruits are with many seed cavities, some of them breaking the central core and giving a most desirable center of evenly-colored flesh. The reciprocal of this—that is, the original cross upon the "Marvel"—had four red and one pink-fruited plants. They were practically the same as the above in all desirable qualities. A slice-view of a fruit is shown at 8, in Plate V.

The "Magnus-Ponderosa" Family.

In the "Magnus" we have one of the most valuable of the coarse-leaved, standard tomatoes which was introduced by Livingston, and it has become quite popular for its fine, evenly-maturing, medium-sized, apple-shaped pink fruits. The primary cross for this family was made some years ago, and the third generation was grown in considerable numbers in the Gardens the past season. Plate VI., of the report for 1904, shows the foliage and fruit of this cross in connection with those of both parents. There are two types of plants in the cross of coarse and fine-leaved sorts, and the block of thirty plants from the same fruit showed seven of the coarse and twenty-three of

the fine-leaved type. As to the character of the fruit and time of maturing there seems to be no difference, but in point of yield the plants with ordinary foliage outrank those of the "potato" type. In general, the fruits are like both parents—of a handsome pink and somewhat variable in shape. Some plants favor in this the "Ponderosa," while the larger number are globular, like the "Magnus," and lacking in the ribbed or angular form of the former variety. While not to be classed among the strictly early sorts, this cross is one well suited to give through a long season a full crop of handsome pink fruits that ripen evenly and yield a larger percentage of flesh than many standard sorts. The reasons for the selection of these two sorts have been given in previous reports, and the results show a combination of qualities that makes it superior to either parent. The objectionable shape and uneven ripening of the "Ponderosa" are removed, with a gain of size and percentage of flesh over the "Magnus." The yield is large and the season long. From one plant sixteen marketable fruits were picked at one time, all of them large and smooth enough for the choicest fruit and weighing six pounds and four ounces.

A considerable quantity of seed was saved from the best fruits of the best plants, which will be distributed in time for the next season.

Other members of the "Magnerosa" family were grown in the usual number—that is, a row of five plants—as follows: The male parent upon the cross 75 (75 x 103), giving what may be termed a three-quarter blood of the "Magnus," produced three coarse-leaved and two fine-leaved plants, with fine, medium-sized, round, smooth fruits, that did not show much of the "Ponderosa" characteristics. The cross worked upon the male parent (75 x 103) 75 was represented by only two plants, one of which was coarse and one fine-leaved. Here the "Ponderosa" was more in evidence in the irregularity of the fruits, but the instances were too few for any generalization. There is a strong individuality among plants of the best established varieties. The female upon the cross 103 (75 x 103) had five plants, all fine-leaved, but among the fruits there was less uniformity. Four plants had the fruits large and irregular and scarcely an improvement upon the "Ponderosa" in this respect, while the fifth bore round fruits of remarkable smoothness, from which seeds for further testing were saved. The cross upon the female parent (75 x 103) 103 gave fine-leaved plants which bore a large crop of fruit, and here, again, four plants strongly resembled the "Ponderosa" in irregular fruits, while one was prolific in fine, medium-sized tomatoes of a desirable length.

The number of plants in each row was so small that it is not safe to draw any conclusions as to the characteristics of reciprocals, but so far as this family is concerned there does not seem to be any difference which is the male and which is the female parent of a second cross when one of the units in the cross is the primary cross of the two bloods that are mingled. In other words, so far as the present test goes, there does not seem to be any difference whether "Magnus" is used as a male or a female to be bred to the cross of that variety upon "Ponderosa." A study of the members of this "family" shows that when "Magnus" represented three-quarters it was able to obscure the "Ponderosa" type of fruit quite extensively, and when the "Ponderosa" was three-quarters it in turn was dominant. There were enough exceptions, however, among the small number of plants to lead to the opinion that strong outcropping of the quarter-blood may be expected in such double crosses. Slice-views of fruits are given at 10 and 11, of Plate V.

The "Mikado-Princess" Family.

In this combination the two parents are of the coarse-leaved, standard type, the "Mikado" having green foliage and the "Princess" of a yellow color. The fruits are pink in both varieties. The primary cross was represented by five plants, all coarse-leaved, which produced large, fine, smooth fruits, with some russet upon the shoulder. In the cross of the male parent upon the cross 89 (89 x 109) the five plants were all coarse-leaved, but not satisfactorily prolific. The reciprocal of this, namely (89 x 109) 89, gave five plants practically the same as the last. Among the five plants of the female upon the cross 109 (89 x 109), three were coarse and two fine-leaved. Two of them were with yellow foliage and none were productive. The reciprocal of this last, namely (89 x 109) 109, gave five coarse-leaved plants, two of which had yellow foliage, and none were satisfactory in yield. It is seen that this cross among the coarse-leaved sorts did not produce plants with abundant fruit. The tomatoes produced by the parents and offspring in this "family," while of superior form, color and firmness of flesh, do not apparently warrant consideration, except by those who wish to have them as interesting types quite different from the quick-growing, prolific sorts.

It is also noted that the four yellow plants out of the twenty-five in the "family" were all among the two reciprocals where the yellow

parent ("Princess") was the three-quarter blood. Had a larger number of plants been employed for each secondary cross, it is likely that the yellow plants would have been found in them all. This assumption is based upon the fact that there was no apparent blending of the yellow and green qualities, and the former is a unit character that follows the Mendelian law. Slice-view of a fruit is shown at 9, in Plate V.

The "Stone-South Jersey" Family.

The "Stone" is one of the most popular of the later varieties of tomatoes—in fact, it is one of Livingston's best in his long list of excellent sorts. It is a standard, fine-leaved, red-fruited, productive variety, medium in size and season, that was exceeded by but few in the score made in 1904. The fruit is solid, with a thick wall, ripens evenly and carries well. The "South Jersey" is a leading red sort among the early group because of its quick growth and large fruits. The latter are, however, very irregular and in striking contrast with the smoothness and uniform size of the "Stone." The first cross—that is, the "Stone" upon the "South Jersey" (123 x 119)—gave large plants, and, as expected, the foliage was of the ordinary sort, like both parents. The fruits were very large and quite irregular, but much superior to the "South Jersey" in this respect. The cross of the male parent upon the first cross 122 (122 x 119) gave large plants, with medium fruits that were comparatively smooth, but there was a lack of productiveness. The reciprocal of this (123 x 119) 123 produced very large and productive plants, with large fruits, that were irregular. The field note-book records that this cross might be good for canneries. There seems to be some difference between the reciprocals in this case of inbreeding. When the "South Jersey" is bred to the cross 119 (123 x 119) more earliness is obtained than in the last-named union of the same varieties, in other words, where there is three-quarters of the "South Jersey" blood. The fruits here were many, quite flat and cracked somewhat. The reciprocal of this, namely (123 x 119) 119, gave less objectionable fruits than the last and were a decided improvement upon the "South Jersey." There may be some loss in speed, but that remains to be determined.

The "Dwarf Stone-Dwarf Champion" Family.

In this group are combined two of the superior members of the dwarf class of tomatoes. The "Dwarf Stone" is a large, firm-fleshed, red-fruited sort that led in points of excellence in our trials with nearly two hundred competitors in 1904, while the "Dwarf Champion" has a much smaller fruit of a pink color. There is little to be said of the five sets of plants that constituted the family. The plants in all cases were dwarfs, as might be expected. The half-blood parent did not differ materially from the reciprocal quarter and three-quarter bloods. One point of interest was the apparent blending in the color, it being in all cases a dull red, instead of in part red and in part pink. The plants were all small, feeble and unproductive. The fruits that came to maturity were of good shape.

The "Ignotum-Red Peach" Family.

The "Ignotum" (62) is a standard, fine-leaved variety of tomato with red fruit, of medium size and earliness that gave with us a score of 83 good points out of a possible 100, in 1904. Its origin is unknown, it having made its appearance in the trial grounds of the Michigan Agricultural College twenty and more years ago, and has been a popular variety for a long time. The "Red Peach" (178) is a small, pink-fruited variety, the foliage of which is of a bluish tinge, and quite susceptible to drought and other unfavorable conditions. In the greenhouse, for example, the peach "blood" can be detected as well by the wilting, when water-supply is limited, as by every other leaf or stem peculiarity. The fruit, aside from its small size and few —usually three or four—large seed cavities, is characterized by a fuzz upon the surface, from which fact the name is given to this quite distinct group.

The second generation of the cross (62 x 180) gave vines of remarkably large size, all five with pink fruits, two of which bore the characteristic peach fuzz. The fruit, in size, varied greatly, some vines bore small tomatoes in large clusters, while others had smaller clusters with the fruit large enough for market. The cross of the male parent upon the cross 62 (62 x 178) produced medium-sized fruits, all red and none with the fuzz, and as a whole inferior. The cross upon the male

parent (62 x 178) 62 produced unusually large plants, with their fruit all red, smooth, medium large, fine-shaped and prolific. This was a very even lot of tomatoes and quite different from the reciprocal last mentioned. In the cross of the peach upon the cross 178 (62 x 178), the five plants were all late in maturing their fruit, which was without the fuzz and in color and shape a fine, red plum. The fruits were in large clusters, all nearly alike and produced in great abundance. Of the reciprocal (62 x 178) 178, there were only two plants, and they produced plants of the peach type.

The "Ignotum-Red Plum" Family.

The cross of the "Ignotum" and "Red Plum," in its second generation, produced standard, fine-leaved plants, with fruit varying from a good-sized to a large, red plum. The male parent upon the cross 62 (62 x 180) gave very large, long plants, with red fruits, some of the large plum type, while other plants bore a good, medium tomato in enormous clusters. One cluster had nine ripe fruits at one time. The reciprocal (62 x 180) 62 gave the same results. When the plum was bred upon the cross 180 (62 x 180) plants with quite uniform fruits resulted, all of them being of a large plum type and very productive. The reciprocal (62 x 180) 180 produced uniformly the plum type and nearly the same as the last, but wonderfully prolific. In case of the need of a good-sized, plum-shaped fruit, this combination would seem to be very desirable.

Time and space admit of only a few general remarks concerning the results when the "families" are not fully represented.

It was impossible to have the plants ready for setting at the same time, and the question of comparative earliness must be left for future tests to determine. The young plants were set out from March 25th to as late as the 15th of May, and it is not fair to compare varieties as to relative earliness unless they are grown during the same dates. A week in June is worth more than the same time in April. Many points of a general nature were, however, recorded as to the behavior of the plants. For example, the crosses between "Acme" and "Bright and Early" are undoubtedly early, and some of them good-sized fruit and very prolific. In those combinations where the "Bright and Early" is three-fourths, the results indicate that a good tomato for forcing may be in sight. By breeding the "Earliana" with "Bright

and Early" a better fruit is obtained than in either parent. The "Earliana" loses somewhat in size, but its shape is improved and there is a better ripening at the "shoulder," with less inclination to crack.

The "Magnus-Crimson Cushion" crosses are full of promise, because of the large, vigorous vines and exceptionally fine fruits. The two parents do not blend as thoroughly as in many instances; and two types in both character of leaf and also of fruit are apparent—that is, there are the coarse and fine-leaved and the red and the pink sorts, besides the tendency of the "apple" shape of the "Magnus" and the more flattened form of the "Cushion" to be in evidence. It is this combination that shows a strong tendency to a marked reduction in the number of seeds, and in the greenhouse plants the fruits were often seedless. Slice-view of a fruit is shown at 7, in Plate V.

The "Arcadia-Cumberland" combinations gave prolific plants with remarkably bright red fruits of desirable size and shape.

In the "Arcadia-Earliana" crosses the most prominent feature was the earliness, with the fruits quite flat and smooth. The plants quickly became prostrate and the crop was gone before neighboring crosses were in full fruitage. Somewhat opposite to this resulted from the "Stone-Earliana" combination, but here there were two types among the crosses, the one favoring the "Stone," with fine, apple-shaped fruits with a long season, and the other flat-grooved with an early short season, like the "Earliana."

The "Stone-Favorite" crosses gave a good showing of fine, smooth fruits, thirteen plants bearing red and six pink tomatoes. Aside from these two types in color there were other indications, as variable size of plant and fruit, that much selection will be necessary to fix the desirable qualities. Slice-view of a fruit is shown at 2, in Plate V.

The "Honor Bright-Fortune" plants were set late, but they gave a large yield of remarkably fine, smooth fruits that were with thick, firm walls, and no doubt of high shipping and keeping qualities. The double cross with three-fourths of the "Honor Bright" "blood" showed four of the five plants with yellow foliage, with fruit that passed through the "white" conditions on the way to the mature red. Similar results were obtained in the "Honor Bright-Freedom" combination, where three out of ten of the thirteen plants were with yellow foliage and the white, immature fruit. There is a strong objection to the foliage, being of a color to suggest that some disease is sapping the life of the plant. Such plants in these crosses, however, gave a

good yield of fruit of fine quality. Slice-views of fruits are shown at 3 and 4, in Plate V.

The "Giant-Frogmore" crosses gave very large plants with irregular, flat, red fruits, with the core inclined to be solid and greenish. When the "Giant" was the female, as in the "Crimson Cushion-Giant" combination, the results were somewhat similar. In short, the "Giant" seems to have great power in producing strong plants that are long in bearing and produce a large, "meaty" fruit that, while of special value for the canneries, may not be otherwise desirable. However, out of these crosses it is probable that a variety with a large, smooth and solid fruit may be secured. Slice-view of fruit is shown at 5, in Plate V.

The "Crimson Cushion-Marvel" crosses were limited to fifteen plants of three combinations. In the original or half-blood union the plants were large and prolific of large, smooth fruits. Two types were manifest—the "apple" of the "Marvel" and the flattened form of the "Cushion." The color was bright red, and the number of seed cavities reached as high as twenty, with few seeds. The row of three-quarter "Cushion" blood gave large plants with nearly smooth, large, red fruits, recorded in the note-book as "prolific * * remarkably fine." The corresponding row of three-quarter "Marvel" blood produced very strong plants, bearing large red, nearly smooth fruits, with note-book remark: "One of the best rows in the field." Whenever either of these two parents has been in combination good results have obtained. Those with "Ponderosa" are given elsewhere under the "Ponderosa-Marvel" family.

In the "Stone-Michigan" cross a very even lot of thrifty plants was obtained with medium large fruits of a bright, cherry-red color and exceedingly uniform in size, inclined to the "apple" form." The "Stone-South Jersey" combination was less uniform than the last, owing to the great dissimilarity of the two parents. The very irregular fruit of the "South Jersey" was not overcome, but greatly improved by the "Stone," giving a flat fruit that was nearly smooth and little ribbed at the stem end. When the "Stone" blood was increased to three-fourths by breeding "Stone" upon the cross, the fruits became smooth, but the plants were not prolific. There was quite a difference between the reciprocals here, for the cross upon "Stone" produced irregular fruits in great abundance, suggesting a good type for truckers to grow for the canneries, as the fruits, while large and rough, were very solid. It is quite certain that five plants are not enough from

which to form an opinion of the worth of any cross, much less to decide upon the effects of reciprocal breeding.

Of the "Ponderosa-Sutton's Best of All" cross there were only the cross itself and the "Ponderosa" bred upon this cross. The first gave all red-fruited plants, while the latter three red and two pink. It was evident that the pink-fruited plants were quite close to the "Ponderosa" in other points. The red fruits were inclined to crack upon the shoulder.

The "Dwarf Stone-Golden Queen" cross brought together two types of tomatoes (1) as to size of plant and (2) color of fruit. There were two sets of this cross—that is, between the two varieties from different seedsmen and of the thirty plants, twenty-five were standard and five dwarf. Of these, fourteen were red and six yellow, and two sets of five each of an orange color, as if the two colors had blended. The last made up the two rows where the "Dwarf Stone" was bred upon the cross, in which there were eight standard and two dwarf plants. The cross as a whole was not productive.

The "Aristocrat-Golden Queen" was a case similar to the last, with seventeen plants in four combinations, in which there were five pink (two pink-orange), five yellow and seven that were a blend. The plants were a small standard and as a whole undesirable. The original "Aristocrat" of this cross, the seed of which was purchased in 1903, is red-fruited and resembles the "Dwarf Champion."

The Lemon Blush-Aristocrat" cross again brought standard yellow and dwarf pink into combination, of which there were thirty-two plants, all standard, in two sets, with the following display of colors: Red, one; orange-red, one; reddish pink, four; yellow, six, and twenty of a blend—that is, a pink with a strong showing of yellow. The yield was not satisfactory as a rule. In the "Lemon Blush" is remarkable vigor of plant, which shows itself prominently in all its crosses.

In the "Dwarf Stone-Aristocrat" cross there were twenty plants, all dwarf and red-fruited, as expected, but the plants, without exception, were stunted and quite unproductive.

The "Lemon Blush-Dwarf Champion" cross is another combination of a standard yellow with a dwarf, pink-fruited sort. Of the twenty-one plants, there were eighteen standard and three dwarfs—four red, two dull red (a blend of pink and red), ten pink and five yellow. One pink and two dull red made up the three dwarfs.

The "Dwarf Stone-Extra Early Tree" cross had twenty plants, of which fourteen were standard and six dwarfs and all red-fruited, with the exception of one yellow. The tomatoes were uniformly large, smooth and usually with a long axis, but not produced in abundance. Two showed the "Mosaic" foliage and a mottling of the fruit.

In the "Crimson Cushion–Sumatra Fig" cross the type and color of fruit differed in the parents. The fifteen plants gave twelve red and two yellow, with a remarkable range of variation in the size of the fruits. Thus in the simple cross of four plants there were two with medium-sized, flat, angular fruits and two of a large plum type and a strong indication of yellow. When the large, red-fruited parent was bred upon the above cross one plant produced large, flat-ribbed tomatoes, one large, long "plums" and the others were intermediate. Upon the other hand, when the "Fig" was three-quarters, the six plants—three red and three yellow-fruited—produced "plums," but varying much in length. The "Cushion" fruit showed somewhat in only one of the plants.

Among the double crosses it is noted that when the "Ignotum-Red Plum" was bred upon the "Magnus-Ponderosa" the five plants were all standard, fine-leaved, and four with red and one with pink fruits. The large vines were enormously productive of large plum fruits. The "Red Plum" seemed to be able, in this combination, to control the size quite fully.

A double cross between "Magnus-Ponderosa" upon "Currant-Stone" gave plants all showing the "Currant" foliage strongly present, that bore abundant red "cherry" fruits, variable in size and undesirable save for pickling.

The "Currant-Stone" was bred upon "Earliana-Fortune," and there resulted extremely "viney" plants that bore a large, red "plum" fruit. Practically the same result was obtained with "Ignotum-Red Plum" upon "Earliana-Fortune." The two double crosses were easily distinguished in the foliage. A single small-fruited sort is able to show controlling power over three of the large-fruited sorts, the size of which has been acquired by selection, etc.

One plant of the three grown of the double cross of "Magnus-Ponderosa" upon "Dwarf Stone-Extra Early Tree" produced remarkably fine red, smooth, apple-shaped fruits, from which there is hope of developing a tomato with exceptionally long axis, combined with good size.

A double cross of some interest was that of the "Aristocrat" (149), with red fruit, upon the cross of "Lemon Blush" (147), a yellow fruit tinged with red, and the "Dwarf Champion" (153), having a pink fruit. In the first place, all five of the plants were standards, approaching the "Lemon Blush" type in size and vigor, and the fruits, as judged by the color chart, were a pure orange in some instances, and all were of that color upon the shoulder, with admixture of red toward the blossom end.

Second Generations Only.

In the following the second generation only were grown—that is, there was no crossing of either parent with them:

"Freedom/King Humbert" (54/64).
"Ignotum/King Humbert" (62/64).
"Marvel/King Humbert" (77/64).
"3151/King Humbert" (3151/64).
"3151/Yellow Pear" (3151/185).
"3151/3147."

The following first crosses were grown:

"Stone/South Jersey" (122/119).
"Currant/Golden Queen" (177/144).
"Red Plum/Golden Queen" (180/144).

Plate V. shows specimen fruits in sectional view of twelve different crosses. The card bearing the record fractional number is a one-inch square, from which the size may be judged. No attempt was made to select more than an average fruit, and they were taken quite late in the season, after the plants had passed their prime. At 1 is the double cross of "Fortune-Earliana" upon "Earliana," showing that the center is thoroughly broken; 2 is "Stone" upon "Stone-Favorite," in which the center is still more divided up into small seed cavities. At 3 is "Honor Bright-Fortune" upon "Fortune"—an oblong fruit with an excellent interior, while 4 shows one of the same cross with three-fourths of "Honor Bright" "blood." Number 5 is "Giant-Frogmore," and 6, "Honor Bright-Frogmore." At 7 is a view of "Magnus-Crimson Cushion" cross—a large fruit with a meaty center, and number 8 gives a small specimen of "Ponderosa-Marvel." A view of "Mikado-Princess" is given at 9, and a second generation fruit of "Magnus-Ponderosa" at 10, with the third generation at 11. An "Acme-Stone" view is seen at 12. In order to bring out the parts more distinctly, the slices were permitted to dry somewhat, so that the pulp has shrunken from the walls a little.

List of the Crosses Grown in 1905.

Below is given a list of the crosses of tomatoes grown in the Gardens during the season of 1905.

The first column gives the crosses all in their second generation, and the other upright lines indicate the form of the breeding of the cross with the parents. Thus, in the second column, it is the male parent upon the cross, indicated by the letters m. p. over x $(\frac{m.\ p.}{x})$ The middle column is the cross upon the male parent, as shown in fractional form by the signs $\frac{x}{m.\ p.}$, and the fourth and fifth columns deal with the combination of the cross with the female parent (f. p.) in reciprocal.

Primary Cross.	Male Parent Upon Cross. m. p.	Primary Cross Upon Male Parent. x	Female Parent Upon Cross. f. p.	Primary Cross Upon Female Parent. x
"Arcadia/Acme" (4/2)	x	m. p.	x	f. p.
"Acme/Arcadia" (1/5)	"	—	"	"
"Acme/Bright and Early" (2/14)	"	—	"	"
"Earliana/Bright and Early" (37/14),	"	"	"	—
"Magnus/Crimson Cushion" (75/26)	"	"	"	—
"Arcadia/Cumberland" (4/28)	"	—	"	"
'Arcadia/Erliana" (4/34)	"	—	"	—
"Stone/Earliana" (121/36)	—	—	"	"
"Stone/Favorite" (121/49)	"	—	"	"
"Earliana/Fortune" (33/53)	"	—	"	—
"Honor Bright/Fortune (60/53)	"	—	"	"
"Earliana/Freedom (33/54)	"	—	—	—
"Giant/Frogmore" (56/55)	"	—	"	"
"Honor Bright/Frogmore" (60/55)	"	—	—	—
"Crimson Cushion/Giant" (26/55)	"	—	"	"
"Crimson Cushion/Marvel" (26/77)	"	—	"	"
"Ponderosa/Marvel" (103/77)	"	"	"	"
"Crimson Cushion/Matchless" (26/81),	"	—	—	—
"Crimson Cushion/Mayflower" (26/83),	"	—	—	—
"Potato Leaf/Michigan" (104/85)	"	—	"	"
"Stone/Michigan" (123/85)	"	—	—	"
"Potato Leaf/Minnesota" (104/87)	—	—	"	"
"Magnus/Ponderosa" (75/103)	"	"	"	"
"Mikado/Princess" (89/109)	"	"	"	"
"Stone/Quicksure" (121/110)	—	"	—	"
"Stone/South Jersey" (123/119)	"	"	"	"
"Acme/Stone" (1/121)	"	—	"	—
"Currant/Stone" (177/122)	—	"	"	—
"Ponderosa/Sutton's B. A." (103/128),	"	—	—	—
"Currant/Sutton's B. A." (177/128),	—	"	—	"
"Red Pear/Wonder" (179/141)	"	"	"	"

Primary Cross.	Male Parent Upon Cross.	Primary Cross Upon Male Parent.	Female Parent Upon Cross.	Primary Cross Upon Female Parent.
"Quarter Century/1903" (165/143)...	"	—	"	"
"Df. Stone/Golden Queen" (170/144),	"	"	"	—
"Aristocrat/Golden Queen" (151/145),	"	—	"	"
"Df. Stone/Golden Queen" (169/145),	"	—	—	—
"Lemon Blush/Aristocrat" (147/149),	"	—	"	—
"Lemon Blush/Aristocrat" (147/150),	"	"	—	"
"Df. Stone/Lemon Blush" (171/150),	"	—	"	"
"Lemon Blush/Aristocrat" (147/152),	"	—	"	"
"Df. Stone/Aristocrat" (171/152).....	"	—	"	—
"Lemon Blush/Champion" (147/153),	"	"	"	—
"Df. Stone/Champion" (171/153)....	"	"	"	"
"Atlantic Prize/Champion" (6/154)..	—	"	—	—
"Lem. Blush/Champ. Scar." (147/156),	"	—	—	—
"Champion/Champ. Scar." (153/156),	"	—	—	—
"Champion/Dandy Dwarf" (153/158),	"	—	—	—
"Stone/E. E. Tree" (171/159).......	"	—	"	"
"Champion/Quar. Cen." (153/165)..	"	"	"	—
"Sta. Yellow/Df. Stone" (210/169)..	"	—	"	—
"Red Cherry/Currant" (176/177)....	—	—	—	—
"Red Peach/Currant" (178/177).....	—	—	—	—
"Yellow Cherry/Currant" (183/177)..	—	—	—	—
"Ignotum/Red Peach" (62/178).....	"	"	"	"
"Ignotum/Red Plum" (62/180)......	"	"	"	"
"Crim. Cushion/Sum. Fig" (26/181)..	"	—	"	—
"Ponderosa/Sumatra Fig" (103/181)..	"	—	"	—
"Crim. Cush./Yellow Pear" (26/185)..	"	—	—	—
"Earliana/Yellow Peach" (37/186)...	"	—	—	—
"Potato-leaf/Yellow Plum" (104/187),	"	—	—	—

Novelties or Varieties Not Before Grown in the Gardens.

All the varieties are of the standard, fine-leaved type, excepting No. 191, which is a dwarf, and No. 195, which is of the "currant" type.

No. 188. "Alice Roosevelt." Plants without much vigor and productiveness. The fruits are red, smooth and medium-sized, with a tendency to be somewhat pineapple-shaped.

" 189. "Baltimore." Plants medium and fruits large, smooth, but much flattened.

" 190. "Buist's Beauty." A heavy bearer of large, nearly smooth, bright red fruits. This is one of the most promising of the list.

" 191. "Burbank's Pickling." This is a dwarf with the foliage closely set and coarse. The fruit is very small, like the "cherry" type.

" 192. "Cluster." The plants soon become prostrate and the fruits, in clusters, lie upon the ground. The fruits are red and quite irregular and flat. The yield is, however, large and early.

No. 193. "Comrade." The red fruits, while many, were only medium to small in size.

" 194. "Globe." Liv. This had the finest fruits of the list, which were a fine pink and large and long. The yield was neither large nor early.

" 195. "Grape." There seemed to be no distinction between this and the "currant" type, and, therefore, was of no special value.

" 196. "Hawkins' Sunrise." This, while early, yielded medium large, red fruits, which were quite irregular and undesirable.

" 197. "Hustler." Here was a variety that showed some earliness, but the red fruits were irregular and small.

" 198. "I X L." This was one of the first to produce ripe fruits, which were red and of medium size. Inclined to decay.

" 199. "Majestic." It was one of the late sorts with red fruits, being smooth, large, but subject to decay.

" 200. "New Century." The fruits (red) were medium, somewhat irregular and fairly early.

" 201. "Pioneer." This gave a pink fruit, of medium size, in fair quantity.

" 202. "Presto." Here was a smooth, small, red-fruited sort, that yielded well.

" 203. "Prize Belle." A very variable set of plants, mostly with medium small, red fruits.

" 204. "Radium." This was a medium late, pink sort, that was not up to the average.

" 205. "Red Cross." A medium small, red-fruited variety, of fair yield, but rotted badly.

" 206. "Redfield Beauty." This was a sort that produced pink fruits, of fair size, that rotted badly.

" 207. "Tenderloin." A late sort that did not show special merit.

" 208. "Boston Market." This gave irregular, red, early fruits, of medium size.

" 209. "Puritan." A few fruits were produced through a long season.

" 210. "Station Yellow." This variety was assigned a number at the end of the list.

Two additional numbers were added late in the spring:

No. 211. "Puget Sound Special." Through the kindness of Mr. W. D. Ennis, a packet of seed of the tomato named above was obtained. Under the very trying conditions for growing tomatoes in the far Northwest, this local variety did much better than any other sort. In our Gardens the plants were of the dwarf type and made less vine and fruit than almost any other kind among which they grew. The fruits were of fair size and smoothness.

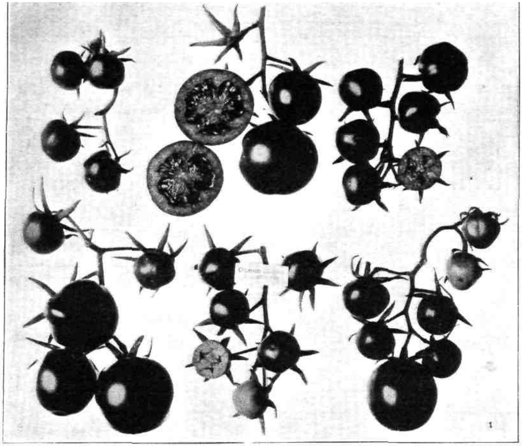
No. 212. "Washington." The seed of this tomato was kindly sent to the Experiment Station by its originator, Professor C. A. White, of Washington, D. C., and ten plants of it were grown in the Gardens, with 212 as its list number. The seed was not received in time to be sown with the other novelties, and therefore the plants were late in coming into bearing. The "Washington" produced a small plant with the strictly dwarf or upright habit, bearing closely-set leaves of the kind commonly met with upon dwarfs, as those of "Aristocrat" or "Champion." The flower clusters were unbranched and the fruit of good size, being pink in color and comparatively smooth, with the center broken and the seed cavities, six or more, like the "Acme," which has a somewhat smaller fruit. The wall is thick and the whole fruit quite closely resembles that of the cross between "Magnus" and "Dwarf Champion." None of the ten plants yielded well. Some crosses were secured particularly with the "Acme," and a quantity of seed was saved from hand-worked flowers.

The First Picking of Tomatoes, July 14th, 1905.

No. 4. "Arcadia." Two fruits, very small, flat.
" 34. "Earliana." Four fruits, large, not cracked, good shape.
" 42. "Early Ruby." Eight fruits, fair size, flat, irregular, not cracked.
" 65. "King of the Earlies." Four fruits, fair size, flat, irregular, not cracked.
" 77. "Marvel." Two fruits, fine shape, smooth, one of the best.
" 89. "Minnesota." Three fruits, small, long, suggestion of peach "blood."
" 94. "Noltes' Earliest." Seven fruits; very irregular in shape and size; one had good length, size and shape.
" 119. "South Jersey." Two fruits, inferior in all things excepting color.
" 188. "Alice Roosevelt." Three fruits, cone-shaped, good size and color, some signs of cracking.
" 198. "I X L." Two fruits, very irregular and inferior.
" 200. "New Century." Three fruits, cone-shaped, good size, poor color, resembles "Alice Roosevelt."

"Seedless" Tomatoes.

During the present season twenty-five plants were grown of the so-called "Seedless," which is a tomato that came to light originally among a plot of plants that were a cross of "Golden Sunrise" upon the "Dwarf Champion," made in 1899. It was at the outset remarkable for its great size, and was called the "Giant" on that account. The seedlings frequently bear three cotyledons, and the plants are very slow, growing long-stemmed, with the foliage open, due to the long internodes, and leaves with the divisions widely separated, which are crinkled, and the terminal leaflet blunt-pointed. The flower clusters



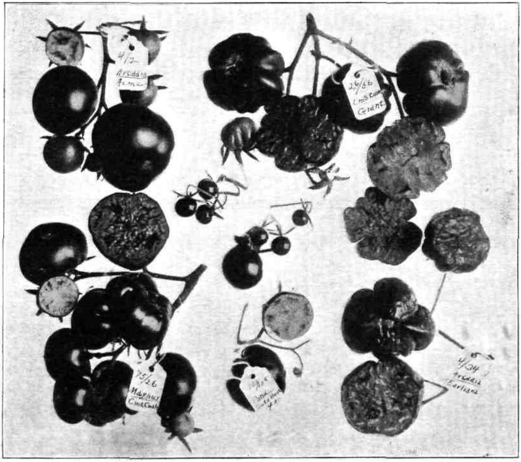


PLATE VII.

Several crosses grown in greenhouse, showing Seedless Mature Tomatoes and some that were normal. The labels are three-fourths inch wide.

are small, flowers cup-shaped, light lemon-yellow, and the fruits few, medium small, light yellow and nearly seedless. The flesh is particularly fine flavored. The plants, three feet apart each way, covered the ground devoted to the block, and flowered up to the killing frosts near November 1st.

The plants of this season were not unlike those of previous years, and the type seems to be well fixed. All attempts to cross any other sort upon it have uniformly failed, and the only way to get a half-blood seems to be by using this one as the pollinator. Two plants were grown in the greenhouse last winter for this purpose, but no crosses were obtained upon it or with it upon other varieties.

There was another type of seedlessness met with in the greenhouse that is illustrated in Plate VII. It was first observed that certain young fruits of the hybrid of "Currant" upon "Stone" ceased to enlarge and began to turn of a pale green, while others in the long, slender cluster continued to grow until several times the size of the first mentioned. The color and size of the little fruits were so nearly those of peas somewhat too old for eating that the name "Pea" tomatoes was given to them. In time all the fruits upon a cluster, whether of the size of peas or cherries, ran through the ordinary color changes until they were of the tomato-red, or ripe, condition. The knife reached the truth of the supposition in each case of the small fruit, for they were invariably seedless, and the flesh filled up the interior, with perhaps a small, empty seed cavity.

The same thing was met with later on, when the cross of the "Crimson Cushion" upon "Sumatra Fig" came into bearing. The upper part of Plate VII. shows some of the clusters of this combination between a large and small-fruited variety. Near the middle of the group, where the label—about an inch long—is situated, the whole cluster is of the small, seedless sort. They were all ripe—that is, of a red color—excepting the terminal one. A section through one of the fruits shows that with these there are three cavities well toward the center of the solid flesh. The clusters to the right and left show the size of the seedless, as compared with the seed-bearing fruits, when both are of the same color of maturity. The seedless fruits obtained a certain uniform size that did not differ but slightly from their average. In short, upon these plants there were two distinct sizes of fruits, the one seed-bearing and the other seedless.

The lower portion of the plate shows instances of seedless fruits

that were met with upon other crosses. The "Crimson Cushion," in its combination with "Giant" and "Magnus," gave many seedless fruits that were large enough for the table, being over two inches in diameter. "Arcadia" with "Acme" and with "Earliana" are other crosses with seedless fruits that are shown in the plate. In the middle of this portion of the plate is shown a cluster of the "Currant-Stone" cross with the "Pea tomatoes" and one of normal size. The sectional views of the fruits give an idea of the solidity of the flesh. A practical test of the quality indicated that a tomato may be seedless and still have a superior flavor, but it may, however, be somewhat different from that of the ordinary tomato. In two instances, when they were being tested by unbiased persons and in connection with different lots of these seedless fruits, it was remarked that they had the flavor of strawberries.

The conditions surrounding these plants favored non-pollination and yet stimulated the growth of the flesh of the fruit, and it is assumed that the withholding of the pollen is the primary cause of the peculiar dwarfed fruit above considered. That some varieties produce seedless fruits more readily than others seems a fact, and it will be remembered in the breeding for more flesh and less seeds in tomatoes.

A large number of cuttings were made from the "Magnus-Crimson Cushion" cross that was prominent in its number of seedless fruits and set in the Gardens, where a row of remarkably uniform plants grew and fruited profusely. There were no signs of the small, seedless fruits, although they were frequently looked for. The conditions of the open field seemed to overcome the peculiar tendency so apparent in the greenhouse.

Tomato Plants Transferred from Greenhouse to Field.

The following is a record of a block of tomato plants taken from the greenhouse, where they had borne fruits during the winter, to the Gardens, and grown there for the summer season. The plants were cut back to within a few inches of the soil and permitted to send up small shoots before they were removed from the large pots to the Garden plot.

Upon September 5th the vines were cut near the ground and the following record, showing cross by fraction, was made:

1. $\frac{121}{36}$ produced a small vine with sixteen irregular fruits of medium size.

2. $\frac{4}{34}$ gave a very small plant, bearing only four poor fruits.

3. $\frac{4}{14}$, a small plant with twenty-five very small fruits.

4. $\frac{2}{14}$, a medium plant with forty-five very small fruits.

5. $\frac{1}{5}$, very small plant, bearing twelve medium fruits.

6. $\frac{33}{53}$, medium plant with forty fine fruits.

7. $\frac{121}{49}$, a large plant and fifty fine fruits.

8. $\frac{75}{26}$, plant large and thirty good fruits.

9. $\frac{103}{77}$, small plant and ten small fruits.

10. $\frac{26}{77}$, a medium plant with eighteen large fruits.

11. $\frac{26}{56}$, medium plant with twenty large fruits.

12. $\frac{60}{54}$, a large plant and one hundred medium fruits.

13. $\frac{104}{87}$, a very small plant with ten medium fruits.

14. $\frac{123}{85}$, plant very large and a large number of green fruits.

15. $\frac{26}{83}$, a large plant with fifty good late fruits.

16. $\frac{26}{81}$, plant large, with seventy fine fruits, nearly all green.

17. $\frac{103}{128}$, very viney plant with thirty-five medium fruits.

18. $\frac{89}{109}$, a large, coarse-leaved plant, with forty large fruits.

19. $\frac{147}{150}$, very large plant with ninety good-sized fruits.

20. $\frac{147}{149}$, a medium plant with forty fruits.

21. $\frac{169}{145}$, a large plant with forty medium fruits.

22. $\frac{170}{144}$, small plant and thirty medium fruits.

23. $\frac{147}{156}$, very large plant with a hundred large, mostly green fruits.

24. $\frac{6}{154}$, a medium plant with twenty-five fruits.

25. $\frac{147}{153}$, a medium plant, but with fifty large fruits.

26. $\frac{171}{159}$, a large plant and fifty large fruits.

27. $\frac{153}{158}$, medium plant and twenty medium fruits.

28. $\frac{153}{156}$, medium dwarf with thirty fruits.

29. $\frac{75}{163}$, two plants, large, with seventy fine, large fruits.

The block of transferred plants looked fully as well, in all respects, as those from seeds grown in adjoining plots. An opportunity was offered to make a comparison of the size and structure of the fruits grown upon the same plants in the greenhouse and in the open, and the conclusion is that the superior conditions the Gardens afforded resulted in larger vines and fruits. There was practically no change in the general shape or internal structure of the fruits. The greenhouse fruits are smaller and less irregular than those upon the same plants in the open. In other words, a fruit that is medium large in the open may be expected to be medium in the greenhouse, and one that runs a good, fair size out of doors may possibly be under size under glass. However, a smaller fruit will sell better in the forcing season than when the garden crop is marketed.

Narrow-Leaved Tomato Plants.

Among the three hundred and more crossed plants grown in the greenhouse last winter there was one that, during its later stages of growth, showed leaves with their expansions reduced to long, narrow threads, and not much wider than the midribs. During the past season several of the field plants have shown the same reduction in the foliage, thus giving a peculiar appearance, resembling somewhat that of certain ferns. Such plants are not usually as vigorous as the normal type of the cross in which the slender-leaved form appears. It is not confined to any group of tomatoes, but was met with in both "dwarfs" and "standards," and the "fine" and "coarse-leaved" sorts. As in the single case met with in the greenhouse, the slender form (filiform) does not appear until one or more of the normal leaves have developed. By the time blossoms appear the filiform foliage is in evidence and continues until the close of the season. Crosses with the "Currant" and other small-fruited sorts seem to show more of this abnormality or unusual form than elsewhere. The plants are not fruitful, but close-bred tomatoes were secured to test the stability of this type of foliage in succeeding generations. It may be one of the mutants, that, while interesting as such, does not seem to possess a desirable form of leafage.

Yellow Foliage in Tomatoes.

Certain varieties of tomatoes, as the "Grandus," Honor Bright," "Multicolor," "Princess" and "Dandy Dwarf," have a characteristic yellow foliage, correlated with "white" fruits, which finally turn to the ordinary color upon maturity. Three of these with yellow foliage and "white" fruits are among those that have been crossed, and it may be of interest to give some observations upon the behavior of the above characteristics when bred with the ordinary sorts.

"Honor Bright" was bred with "Fortune," and four out of fifteen plants were yellow; with "Freedom," and three of the fifteen were yellow; with "Frogmore," and one of the ten was yellow. The "Princess" was bred with "Potato Leaf," and four of the twenty plants were yellow. "Dandy Dwarf," with "Dwarf Champion," gave three yellow out of ten plants. In short, out of seventy crossed plants there were fifteen with the "white" fruit and yellow foliage.

In the five cases where the cross showed three-quarter "yellow" blood, there were eleven out of the twenty-five plants with the yellow foliage, and among the six sets (thirty plants) of quarter-yellow blood there were only two of the yellow plants. The two sets of half-bloods showed two out of the ten plants with yellow foliage.

These figures indicate that the yellow character is possibly Mendelian, but it seems to increase as the amount of the blood of the yellow plant is greater and decreases as it is diminished.

Unit Characters Among Tomatoes.

In view of the discoveries of Mendel and others along lines of plant breeding, it may be stated that the work with tomatoes has led to the opinion that there are a number of characteristics among them that follow more or less closely the laws governing the behavior of so-called unit characters.

Starting with the whole plant, is is found that the standard and dwarf types are antagonistic and Mendelian, the former being the dominant character. The same is true of the fine and coarse-leaved (potato) types, the fine dominating over the latter. The yellow foliage, as against the ordinary green type, may be a recessive character, as illustrated in several crosses that have been grown in the Gardens the present season.

In color of fruit the red and yellow follow the law, the red dominating, and the same is true of the pink and the yellow. When the red and pink are bred together the red dominates less evidently.

The characteristic hairiness of the "peach" fruit seems to be antagonistic to that of smoothness in the fruit and dominated by the latter. Thus, in a cross between "Ignotum" (62) and "Red Peach" (178), there were seventeen plants with smooth fruit and two of the true "peach" type.

It is seen that the following pairs in tomatoes seem to fall under Mendel's law of heredity, the dominant character being placed first:

Standard—Dwarf.	Red Fruit—Yellow Fruit.
Fine Leaf—Coarse Leaf.	Pink " — " "
Yellow Leaf—Green Leaf. (?)	Red " —Pink "

Smooth Fruit—Hairy Fruit.

"Mosaic" Disease Among Tomatoes.

Among the crosses of tomatoes there were certain plants which showed a mottled yellow in the foliage all through the season. As a rule, such plants did not flourish and rarely produced more than a few fruits. This trouble resembles the one by the same name in other kinds of plants, prominently the tobacco, and is likely due to a similar cause. The "Mosaics" were generally pulled out to lessen the liability of the trouble being communicated to other plants, but a close watch for it did not reveal it in any plants that were not marked with it soon after they were set in the field. The trouble may be quickly recognized by the angular patches of yellowish green, seemingly distributed without order in the ordinary green of the foliage. Such afflicted plants remain small and are comparatively worthless.

The following crosses showed this trouble in particular: "Arcadia" and "Bright and Early," "Champion" and "Champion Scarlet," "Dwarf Stone" and "Early Tree," "Champion" and "Quarter Century." It appears in the "standards" and "dwarfs," and "fine" and "coarse-leaved" sorts. Seed has been saved from badly-diseased plants with the view of determining whether the offspring of a diseased parent will show the "Mosaic" in particular abundance.

The fruits of "Mosaic" plants sometimes showed the peculiar markings all through their growth, and when mature the areas that lacked the green had a silvery appearance instead of the ordinary color of the fruit.

Color Changes in Ripening Tomato Fruits.

Five fruits, ranging from one the size of a cherry to full size and maturity, were selected from the several types of colors and examined with Prang's color chart. The following table gives some approximate results (Y stands for yellow; G for green; O for orange; R for red; D and L for dark and light, respectively):

Color of Mature Fruit.	Young Fruit.	Half Size.	Nearly Full Size.	Ripening Fruit.	Ripe Fruit.
Red...........	111 YG/DD	102 YYG/DD	52 O/D	52 O/D	42 ORO/D
"Pink"......	105 YGG/LL		45 ORO/L	42 ORO/DD	32 RO/D
"Pink" (yellow foliage)	365? whitish.		"	"	"
Yellow........	102 YYG/DD	115 YG/LL	94 Y/LL	95 Y/LL	83 YYO
"White"......	Color whitish all through—shade not given in the Prang scheme.				

It is seen that the fruits that become red at maturity are of a very dark green at the outset, and gain in yellow until nearing full size, when they become of a dark orange, which is held until near maturity, when the red is mingled with the orange. A "red" tomato is virtually more orange in color than red. It is a dark orange with a dash of red.

The "pinks" start with a light green, showing a little yellow, and the green is gradually replaced by the yellow, until when near full size the green disappears and the yellow is replaced by a light orange, showing a trace of red. From this time on the orange and red deepens until full maturity, when the fruit is a dark red orange. It differs from the so-called "red" fruit in having much more red and less orange. It is this type of fruit that deserves the name of red, while some other term might be given to the group that are more orange than red.

There is a group of tomatoes that is quickly distinguished by the light green or yellowish foliage, giving the plants the aspect of being sick, and in this respect objectionable. The "Grandus" and "Honor Bright" are examples of this among the fine-leaved, and the "Princess" and "Dandy Dwarf" among the coarse-leaved sorts. The fruits here,

while indistinguishable when very small from the ordinary kinds, soon lose the green, as in the foliage, and become whitish, and with some yellow mixed with it remain without much color until full sized, and then run through the color changes to the "red," in "Honor Bright," for example, or the "pink" in "Grandus" and "Princess."

The "peach" is not so green as the first two types when the fruit is quite small, and all through there is a mottled appearance, that, together with the fuzz, makes it difficult to record the color value. When mature the "peach" is practically a "red," "pink" or "yellow," as the case may be, the hairy surface modifying the appearance somewhat.

The yellow group, as might be expected, loses the green in the fruit early in its growth, and, in short, has the color strongly yellow when the size of a cherry. The plain light yellow, unmixed with other color, holds until nearing maturity, when a distinct orange comes in. The amount of this orange varies with the variety and the situation. Some sorts are a lighter yellow than others, while exposure to sun seems to increase the orange—that is, fruits that are thoroughly shaded are a pale yellow, while others upon same plant and fully exposed may be quite orange-colored. In like manner there is a tendency in the yellow-fruited sorts to the development of a red when the fruits have become fully matured in the open sunshine. As with peaches, the side of the yellow fruit that is most exposed is the most highly colored. When the fruit is a "red" or "pink" this difference due to sunshine is not so apparent.

The last group to be mentioned is a small one, represented by such sorts as "Ivory Ball" and "White Apple," which seem to be deficient in the ordinary color pigments, and, starting with a small amount of green, quickly lose it and remain of a pale white until mature.

The following are the running notes upon a lot of "Magnus-Ponderosa" tomatoes of the same age:

March 31st.—Changed from lighter yellowish green (115 YG/LL) to darker yellowish green (101 YYG/DD) on April 1st and until the 5th inst., when the color was changed one point by becoming less dark (102 YYG/D). Upon the 8th orange appeared with the score 72 (YO/D), and upon the 9th the orange was much increased, namely, 62 (OYO/D). Upon the 14th the fruits were dead ripe and the score was 22 (RRO/D). In other words, the green was succeeded by yellow and the yellow by orange, and last, red was added to the orange.

A group of "Station Yellow" crossed with "Dwarf Stone" ran from the dark yellow green quickly into the orange, they being a pure dark orange for one day and then gradually took on red until they became a dark orange-red-orange, 42 (ORO/D) at maturity.

In a general way, the four scales may be expressed as follows:

1. Green..Greenish-white..Yellowish-white.."White"..........."Ivory Ball."
2. Green..Greenish-white..Yellow-orange....Orange-red......"Honor Bright."
3. Green..Greenish-white..Yellow-orange....Orange-red-orange... "Grandus."
4. Green..Greenish-yellow..Orange..........Orange-red-orange....... "Stone."
5. Green..Greenish-yellow..Orange..........Orange-red......... "Ponderosa."
6. Green..Greenish-yellow..Yellow..........Yellow-orange...."Golden Queen."

EXPERIMENTS WITH BEANS.

As a result of "handworking" the flowers among the commercial varieties, seventy pods were obtained during the early part of the season. Seeds from all of these were planted in July and all produced plants, with two exceptions. The absence of killing frosts until near to November 1st favored this summer planting and a majority matured seeds, and nearly all gave evidence of being crosses.

A block of bush beans was planted early in June with a dozen white-seeded sorts, and among these several pods were harvested as results from cross-pollination. Several probable crosses have also been secured between the three varieties (Nos. 155, 158 and 159) kindly sent by Mr. W. W. Tracy, Jr., and planted late in June.

A cross of the "Scarlet Runner" upon bush beans has been secured in several instances and promises to be of unusual interest. In this instance the blood of two species is brought together, namely, that of *Phaseolus multiflorus* and *P. vulgaris*. These hybrids have been grown only for midsummer planting, and a full trial of their power is reserved for next year. Thus far they have all showed a strong tendency to twine with flowers of a quite uniform pink, inclining toward salmon, in place of the bright red ("scarlet") of the male parent.

Like the "Scarlet Runner," its hybrids are profuse bloomers and quite slow to produce pods and form seeds. Such pods as were formed were much smaller than those of the male parent and lacked the roughness of the surface characteristic of the parent. Very late in the season a few pods from four plants were obtained, and these con-

tained seeds that resembled the "Scarlet Runner" in being marked with red, but of much smaller size. It is not likely that this hybrid will prove of value as an edible bean, but it adds another color to the flowers of a thrifty, almost ever-blooming ornamental vine.

The efforts to cross the lima with the bush beans have been continued without results.

Notes upon Bean Crosses.

During the year four crosses of bush beans have been carried forward to their third generation, namely—*first,* "Bismarck" (102) upon "Detroit Wax" (113); *second,* "Jones' Stringless" (131) upon "Golden Eye" (130); *third,* "Davis' Kidney" (111) upon "Bismarck" (102); *fourth,* "Early Mohawk" (31) upon "Silver Bush" (38), and many crosses were carried through the second generation.

The first of the five crosses is expressed in the record-book by the fraction $\frac{102}{113}$—that is, the male ("Bismarck") is one of the black wax type, while the mother is of the golden wax group; the former is black-seeded and the latter is chiefly white, with a large, irregular brown "eye." On account of the color of their seeds the black wax beans are not as desirable as those with white seeds. While there may be no distinct difference in texture or flavor, the dark seeds give a discoloration to the pods, when cooked, that is not pleasing to the eye.

As there is no noticeable immediate influence (xenia) observed in these crosses, the first generation begins with seeds that are, so far as appearances go, the same as those of the mother plant. For example, the seed of the cross of "Bismarck" upon "Detroit Wax" is of medium size and white, with a large, brown eye, like the mother, and shows none of the black of the male parent. The plants of this first generation were medium tall, resembling the male parent ("Bismarck"), maturing early its long, straight pods. The seeds were dark mottled and of medium size, and were the beginning of the second generation of the cross. These plants showed much variation in size, some being quite tall and others short, while the flowers ranged from purple, like the "Bismarck," to white, as found in the "Detroit," and the pods varied from long in the male parent to short in the mother. At maturity three types of seeds were found, namely, plain black, dark

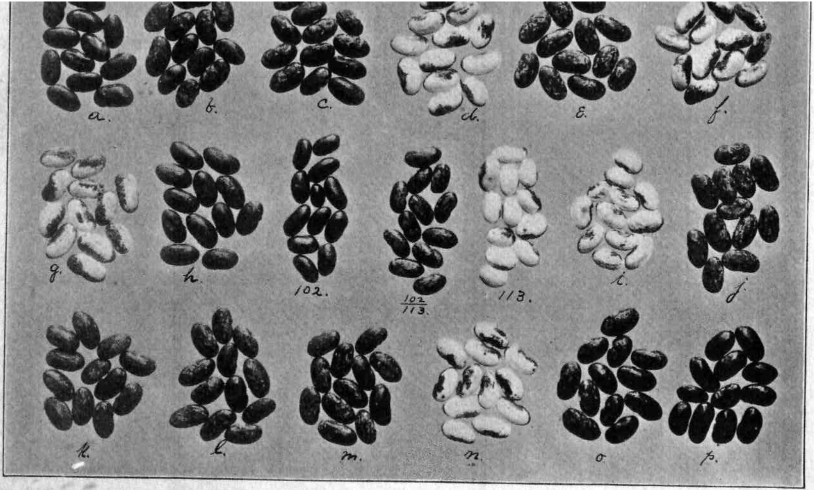


PLATE VIII.

Beans from sixteen plants, *a* to *p*, and beginning the third generation of the cross of "Bismarck" (102) upon "Detroit Wax" (113). The parents are shown with samples of the seeds from the first generation between them in the middle of the group.

mottled and white with a dark eye. In other words, there are the two parent forms and an intermediate.

From the mottled seeds a row of sixteen plants was grown during the latter half of the present season, with the following results as to character of seeds, representing the third generation:

Plant *a*. Seeds largely black, but somewhat mottled.
Plant *b*. Seeds dark, but more mottled than the last.
Plant *c*. The same as the last.
Plant *d*. Seeds white, with the "eye" larger and darker than "Detroit."
Plant *e*. Seeds dark indigo and mottled.
Plant *f*. Seeds white with the indigo "eye" very large, covering a third of the seed.
Plant *g*. Seeds pure black ("Bismarck").
Plant *h*. Seeds white, same as *f*.
Plant *i*. Seeds white, with small dark "eye" ("Detroit").
Plant *j*. Seeds dark indigo and mottled.
Plant *k*. Seeds almost entirely black, obscurely mottled.
Plant *l*. Seeds same as last.
Plant *m*. Seeds same as last two.
Plant *n*. Seeds white, like *i*.
Plant *o*. Seeds same as *m*.
Plant *p*. Seeds a pure black.

A dozen seeds from each of the above plants, with the parents, are shown in Plate VIII.

This row of sixteen plants gives a record, as shown above, of two pure black, like the male parent ("Bismarck") and two of the "Detroit" type, with nine that are black (or indigo) mottled and three which vary from the mother type somewhat. Thus, *a, b, c, k, l, m* and *o* would not be distinguished from each other when mixed together, while *e* and *j* have the black replaced by an indigo. There is a suggestion in this small number of instances that possibly one-quarter of the plants in this cross will reproduce each plant and one-half the mottled or mixed form. In another row of the same cross the eleven plants gave one black, four dark-eyed and six mottled.

The next cross is recorded as $\frac{131}{130}$, namely, "Jones' Stringless" upon "Golden Eye." The male parent is of medium height and productive of straight, rounded, medium length wax pods, maturing early its plain white seeds. The mother has a larger, broader plant than "131," and bears flat seeds, distinguished by a yellow "eye." The first generation consisted of plants like 131 and the seeds were all mottled, of a

grayish color. In the second generation there was much variation, some of the plants producing long, flat pods, others short and flat, while one had a neat, round pod. None of the seven plants produced seeds like the mother of the cross, but they were of four types, namely, (1) white, (2) dark brown mottled, (3) light brown mottled and (4) brown.

In planting for the third generation the dark brown type was inadvertently omitted. All of the plants from the white seeds produced only white seeds, and this indicates that with further generations from this stock no mixing of the brown color may be expected.

The cross of "Early Mohawk" upon "Silver Bush" bears the record fraction of $\frac{31}{38}$. The male parent ("Mohawk") has a large, stocky plant, medium early, with pink flowers, broad, long, flat green pods and dark mottled seeds, while the "Silver Bush" has a small-spreading plant, late in bearing, with white flowers and numerous small, round pods of a "silver" color, with small white seeds. The plant from this cross was of medium size, purple flower, and bore long, flat pods that became striped in maturity and produced good-sized, flat, dark mottled seeds. Some of the plants from this last-named plant—*the second generation*—showed a strong tendency to "run," and could easily have been classed as pole beans. Four of the "bush" type produced wax pods and black seeds. Two other types were present, namely, one with a light brown seed, having a few broad, dark streaks and a dark mottled sort. As yet this cross does not seem to be as prolific as either parent.

Notes upon Bush Beans.

The following table shows in condensed form many of the notes that were made upon the bush beans during the season of 1905:

No.	Kind and Source.	Size of Plant.	Flower Color.	Pod, Shape and Size.	Seed, Size and Color.	Season.
1.	"Best of All," Him	Medium	Pink	Long, flat	Medium, light mottled	Early.
2.	"Bountiful Bush," Hen	"	"	Medium, flat	Medium, brown	"
3.	"Boston Snap," Brk	"	White	Short, flat	Small, white	Late.
4.	"Breck's String and Shell," Brk	"	Pink	Medium, flat	Medium, brown mottled	Med. early.
5.	"Burlingame Medium," Brk	"	"	Medium, round	Dark brown	" "
6.	"Byer's Bush," Chl	"	"	" "	Medium, dark mottled	" "
7.	"Canada Wonder," Thr	Large	"	Long, flat	Large, red	Late.
8.	"Canada Wonder," Cox	"	"	" "	" "	"
9.	"China Red Eye," N. K	Medium	"	" "	Medium, dark eye	Med. early.
10.	"Crystal," Drr	"	White	Short, medium, round	Small, white	" "
11.	"Dwarf Chocolate," Thr	"	Purple	Long, flat	Small, dark brown	" "
12.	"Dun Colored," Thr	"	"	" "	" " "	" "
13.	"Eclair," Thr	"	"	" "	Small, light brown	" "
14.	"Earliest G. Pod," Ham	Large	Pink	" "	Medium, light mottled	" "
15.	"Emperor of Russia," Thr	Medium	"	Medium, round	Medium, dark mottled	" "
16.	"Emperor William," Him	"	White	Long, flat	Large, white	" "
31 17.	"Everbearing," Thr	"	"	" "	Medium, white	" "
18.	"Goddard Imperial," Fer	Large	Pink	" "	Medium, light mottled	" "
19.	"Horticultural Dwarf," Btl	Medium	"	" "	" " "	" "
20.	"Horticultural Dwarf," Hen	"	"	" "	" " "	" "
21.	"Horticultural," N. K	"	"	" "	" " "	" "
22.	"Early Marblehead," Fer	"	"	" "	" " "	" "
23.	"First on Market," Lan	"	White	" "	Large, white	" "
24.	"Land. Scarlet," Lan	"	Pink	" "	Medium, dark red	" "
25.	"Lightning," Thr	"	Striped	" "	Medium, light mottled	Extra early.
26.	"Longfellow," Hen	"	Pink	Long, round	Medium, mottled	Med. early.
27.	"Low's Champion," Ggy	"	"	Short, flat	Medium, dark red	" "
28.	"Marrowfat," Btl	Large	White	Long, flat	Large, white	Late.
29.	"Marrowfat," Him	"	"	" "	" "	"
30.	"Marvel of Paris," Thr	Medium	Pink	Long, round	Medium, dark mottled	Early.
31.	"Mohawk," Drr	"	"	Long, flat	Medium, mottled	Med. early.
32.	"Mohawk," Thr	Large	"	" "	" "	" "
33.	"Mohawk," Bru	Medium	"	Medium, flat	" "	" "
34.	"Prolific Tree," Iow	"	White	" "	Medium, white	Late.
35.	"Refugee," Btl	"	Purple	Long, flat	Medium, dark mottled	Med. early.

No.	Kind and Source.	Size of Plant.	Flower Color.	Pod. Shape and Size.	Seed, Size and Color.	Season.
36.	"Refugee Green," Bru.	Medium	Purple	Long, round	Medium, dark mottled	Med. early.
37.	"Silver," Sal.	"	White	" "	Small, white	" "
38.	"Silver Bush," Man.	"	"	Short, medium, round	" "	" "
39.	"Stringless," Btl.	"	Pink	" " "	Medium, mottled	" "
40.	"Stringless Mammoth," Drr.	"	"	Long, round	" "	" "
41.	"Stringless Dwarf," Thr.	"	"	" "	" "	" "
42.	"Giant," Wd.	"	"	" "	" "	" "
43.	"Tennessee G. Pod," Fer.	Large	White	Long, flat	Medium, light brown	" "
44.	"Earliest R. Valentine," Hen.	Medium	Pink	Short, round	Medium, mottled	" "
45.	"Black Valentine," Hen.	"	Purple	Long, flat	Medium, black	" "
46.	"Stringless Valentine," Btl.	"	Pink	Long, round	Medium, mottled	" "
47	"Early Red Valentine," Btl.	"	"	Short, flat	" "	" "
48.	"Extra Early Valentine," N. K.	"	White	Long, round	" "	" "
49.	"Dwarf Prolific Pickler," Vk.	Large	Pink	Long, flat	Large, red	Late.
50.	"Warren Bush," Ggy.	Medium	"	Short, flat	Medium, red	"
51.	"Green Winter," Sal.	"	White	Short, round	Medium, white	"
52.	"Wonder of France," Brk.	"	"	Long, flat	" "	Med. early.
53.	"Yellow Six Weeks," Btl.	"	Pink	" "	Medium, light brown	Early.
54.	"Yellow Six Weeks," Bru.	"	"	" "	" " "	"
55.	"Light Yellow Six Weeks," Drr.	"	"	" "	" " "	"
56.	"Early L. Yellow Six Weeks," N. K.	"	"	" "	" " "	"
101.	"Burpee's Brittle," Bur.	"	White	Long, round	Medium, dark eye	Med. early.
102.	"Bismarck," Far.	"	Purple	Long, flat	Medium, black	Early.
103.	"Black Wax," Bart.	"	"	Medium, flat	" "	"
104.	"Black Wax," Bart.	"	"	" "	" "	"
105.	"Black Wax," Bru.	"	"	" "	" "	"
106.	"Black Wax," J. & S.	"	"	Medium, round	" "	"
107.	"Black Wax," Thr.	"	"	" "	" "	"
108.	"Black Wax," Thr.	"	"	" "	" "	"
109.	"Black Wax," Cur.	"	"	Medium, flat	" "	"
110.	"Cylinder," Hlm.	"	"	Long, round	" "	"
111.	"Davis'," Btl.	"	White	Long, flat	Medium, white	Med. early.
112.	"Davis'," N. K.	"	"	" "	" "	" "
113.	"Detroit," N. K.	"	"	Short, flat	Medium, dark eye	" "
114.	"Flageolet," Bru.	Large	Pink	Long, flat	Medium, red	" "

No.	Kind and Source.	Size of Plant.	Flower Color.	Pod, Shape and Size.	Seed, Size and Color.	Season.
115.	"Flageolet," Fer.	Large	Pink	Long, flat	Medium, red	Med. early.
116.	"Fullers' J. & S.	Medium	Purple	Medium, round	Medium, black	" "
117.	"Fullers'," Ggy.	"	"	" "	" "	" "
118.	"Golden," Btl.	"	White	Medium, flat	Medium, dark eye	" "
119.	"Golden," Bru	"	"	" "	" " "	" "
120.	"Golden," N. K.	Small	"	" "	" " "	" "
121.	"Golden," Cox.	Medium	"	Short, flat	" " "	" "
122.	"Golden," Hen.	"	"	" "	" " "	Early.
123.	"Golden," Fer.	"	"	Medium, flat	" " "	"
124.	"German Black," Fer.	"	Purple	Long, round	Medium, black	"
125.	"Golden Crown," Thr.	"	White	Medium, round	Medium, white	"
126.	"Golden Wax," Fer.	"	"	Short, flat	Medium, dark eye	"
127.	"Golden Wax," Fer.	"	"	Long, flat	" " "	"
128.	"Golden Wax," Fer.	"	"	Short, flat	" " "	"
129.	"Scimitar," Hen.	"	Purple	Long, round	Medium, black	"
130.	"Golden Eye," Thr.	"	White	Short, flat	Medium, yellow eye	"
131.	"Jones' Stringless," Vau.	"	"	Medium, round	Medium, white	"
132.	"Keeney," J. & S.	Small	Purple	Long, round	Medium, dark mottled	Med. early.
133.	"Keeney," Hlm.	"	"	" "	" " "	" "
134.	"New Round Pod," J. & S.	Medium	White	" "	Medium, dark eye	" "
135.	"Market," Hen.	"	Pink	Long, flat	Medium, light brown	" "
136.	"Pencil Pod," Fer.	Small	Purple	Long, round	Medium, dark mottled	" "
137.	"New Profusion," Mau.	"	"	" "	" " "	" "
138.	"Lan. Scarlet," Lan.	Large	Pink	Long, flat	Medium, red	" "
139.	"Refugee G. P.," N. K.	Medium	Purple	Long, round	Medium, dark mottled	" "
140.	"Stringless," Ham.	"	White	Short, round	Medium, white	Early.
141.	"Saddleback," Hlm.	"	Purple	" "	Medium, black	"
142.	"Wardwell's Kidney," N. K.	Large	White	Long, flat	Large, dark eye	"
143.	"Wardwell's Kidney," Btl.	"	"	" "	" " "	"
144.	"Wardwell's Kidney," Bur.	"	"	" "	" " "	"
145.	"Crystal," Fer.	Small	"	Short, round	Small, white	Late.
146.	"Yosemite," Drr.	Large	Purple	Long, round	Large, black	Med. early.
147.	"Allan's Imperial," Sal.	Small	"	Short, flat	Medium, dark mottled	" "
148.	"Pencil Pod," Liv.	"	"	Long, round	" " "	" "

Novelties in Bush Beans.

A few sorts of beans were grown this season that are not in previous lists of our experiments from No. 1 up to No. 149. The following notes are given, with the list number assigned to each:

No. 149. "Burpee's White Wax." The plants of sturdy growth, with large, broad leaves, are similar to "Wardwell's Kidney" (144), and have broad pods with white seeds.

" 150. "Butter Wax." This is of the "Golden Wax" type (Nos. 118-123).

" 151. "California Black Wax." Having medium length, flat, straight, yellow pods with black seeds. This number is close to the numbers 102-110. It was quite prolific.

" 152. "Eldorado Wax." This is quite similar to 151, but with longer pods.

" 153. "Golden Jersey Wax." This seems to be a selected strain from the "Golden Wax" (No. 118-123).

" 154. "Ventura Wonder." This seems to be an improvement upon the "Davis' Wax" (111-112), with long, yellow pods and a good bearer.

" 155. "Crimson Beauty." This is similar to "Goddard" (18), with the green pods beautifully marked with red. It yielded well.

" 156. "King of the Earlies." This has a desirable pod, long and curved, striped at maturity, and bearing black seeds.

" 157. "Prolific Market." This gave late, "viney," green-podded plants, inclined to run.

" 158. "Silver Refugee."

" 159. "Yankee Winter." This is a green-podded sort, forming small, spreading plants, about the size of "Crystal Wax." and as desirable.

" 160. "Asparagus." This resembles closely the forage plant known as "Cow Pea."

Experiments with "Jackson Wonder" Bush Lima.

The "Jackson Wonder" bush lima bean is remarkably prolific, and were it not for its striped seeds it would be perhaps the leading variety, except with those who insist upon having the large, thick-fleshed bean of the "Burpee" or "Dreer" types. This "Jackson" has a great tendency to vary in the amount of the dark color in the seed, some plants producing those with the seeds nearly white.

In 1904 a block of a hundred or more plants was grown from the darkest selected seeds and another with the lightest seeds to be found in a pound package of the commercial seed. From the crop secured from these plantings, made in widely separated parts of the Gardens, the darkest and lightest seeds were again selected and planted separately.

The result of this second crop does not indicate any great effect of the repeated selection upon the color of the seed. In other words, the light seeds from the light seeds are nearly as dark as those from the second generation of selected dark seeds, a somewhat unexpected result, suggesting that the prolificness of the "Jackson Wonder," combined with white seed, may be more quickly obtained by breeding than mere selection.

EXPERIMENTS WITH EGGPLANTS.

The following is a list of eggplants that were grown in the Gardens the past season, with the source of the fresh seed, number of plants and fruits secured. In case of No. 10 the fruits were allowed to mature, that the seed might be saved, and this doubtless reduced the number of marketable fruits that might otherwise have been produced had they been removed when ready for the table:

Record No.	Name and Source of Seed.	Number of Plants.	Fruits Gathered.
1	"Baltimore," G. & F.	16	24
2	"Black Snake," Thr.	27	198
3	"Black Pekin," Thr.	37	105
4	"Black Beauty," Thr.	20	53
5	"Dwarf Purple," Thr.	15	97
6	"Early Dwarf Oval," Steck.	16	108
7	"Excelsior Tree," Mau.	15	57
8	"Florida High Bush," Wood.	16	72
9	"Giant N. Y. Spineless," Chl.	4	13
10	"Jersey Belle," N. J. Sta.	190	580
11	"Long White," Thr.	8	36
12	"Long Purple," Thr.	11	43
13	"Mammoth Purple," Thr.	17	24
14	"Fordhook Improved"	Failed.	...
15	"Mammoth Pearl," Fer.	8	17
16	"New White Pearl," Evr.	5	17
17	"New Excelsior Tree," Hlm.	20	93
18	"New York Improved," Bar.	9	20
19	"New York Improved Purple," Vau.	12	28
20	"Pride of Sunnyside," Ford.	7	24
21	"Striped," Thr.	7	46
22	"Purple Perfection," Tait.	5	4
23	"Thornless Long Red Purple," Lan.	13	59
24	"New White," Mau.	6	21
25	"Scarlet Chinese," Thr.	25	Very numerous.

The following is a preliminary classification of the above list of eggplants:

Plants Tall:
- Leaves Purple—
  - Fruit slender, "Black Snake" (2).
  - Fruit round, "Black Pekin" (3).
- Leaves Green—
  - Fruit oval, "Excelsior Tree" (7).
    - "Florida High Bush" (8).
    - "New Excelsior Tree" (17).
    - "Thornless Purple" (23).
  - Fruit long—
    - White, "Long White" (11).
    - Purple, "Long Purple" (12).

Plants Medium Tall:
- Fruit Purple—
  - Large, "Mammoth Purple" (13).
  - Medium, "Giant N. Y. Spineless" (9).
    - "Jersey Belle" (10).
    - "New York Improved" (18).
    - "New York Improved Purple" (19).
    - "Pride of Sunnyside" (20).
    - "Purple Perfection" (22).
- Fruits White—
  - Large, "Mammoth Pearl" (15)
    - "New White Pearl" (16).
    - "New White" (24).
  - Small, "Striped" (21).

Plants Medium Short:
- "Baltimore" (1).
- "Black Beauty" (4).

Plants Dwarf:
- "Dwarf Purple" (5).
- "Early Dwarf Oval" (6).

Notes upon above Eggplants.

An opportunity offered for the study of the above commercial sorts of eggplants as grown in the same block of the Gardens, and the following notes are drawn from the record book for the year:

1. "*Baltimore.*" The plants are of a medium dwarf type with light green foliage and giving medium large, oval purple fruits in small numbers. The fruits soon decay without turning orange, as in the plants with purple foliage like "Black Snake," and the true dwarfs (Nos. 5 and 6). The sort nearest to it is the "Black Beauty" (4), from which it may perhaps be distinguished by a lighter purple to the surface of the fruit.

2. "*Black Snake.*" The plants are unusually slender and tall, with the leaves narrow and purple. It is early, but the fruits are so long and slender as to be of little value for the table. The plants continue to bloom and bear fruit until frost kills them. The fruits turn yellow at maturity. It is a spineless variety and on this account is of much value in breeding. From it, in combination with the "New York Improved," has been secured a long, large-fruited cross that is of much market value and has thus far shown no spines.

3. "*Black Pekin.*" This is a distinct variety, as shown by its purple stems and foliage, tall habit of growth and large, nearly spherical fruits, showing the absence of the dark purple color beneath the large calyx lobes. This last peculiarity is shared by the "Black Snake," "Dwarf Purple" and "Early Dwarf Oval." The plants are not very prolific and the fruits are quite inclined to crack before they are large enough for the table. The leaves are much less injured by the potato beetle than those of the green sorts.

4. "*Black Beauty.*" This is so close to the "Baltimore" that the same remarks apply to both.

5. "*Dwarf Purple.*" The dwarf habit (one to one and a half feet high) is so marked that this is a well-defined variety. In the purple color of the stems, foliage and fruit it resembles the "Pekin," but its foliage is long and narrow, more like the "Black Snake," and the fruits are almost pear-shaped and quite small as compared with those of standard sorts and much less rapid in decay. The calyx is purple and the flesh of the fruit beneath its lobes is green. The chief merit of the small plants is in their earliness, producing fruits before any other sort, and continue to bear until late in the season. Old plants sometimes show several straw-yellow, pear-shaped, mature fruits, which, upon cutting with a knife, exhibit much firmness, especially near the surface, while the seed cavities are much better defined than in such fruits as those of the "Pekin" or "New York Improved" type. In other words these dwarfs show a characteristic solidity in the fruit that is quite resistant to the ordinary form of decay in eggplants. It is not spineless.

6. "*Early Dwarf Oval.*" This was grown alongside of No. 5 and no difference could be detected between the two.

7. "*Excelsior Tree.*" This is a tall, broad, green-leaved, late, somewhat spiny sort, with medium-sized, oval, purple fruits.

8. "*Florida High Bush.*" This was grown next to No. 7, and not easily distinguished from it.

9. "*Giant N. Y. Spineless.*" This was represented by only four plants, due to a poor stand in the seed box. The plants were only medium tall, with green stem and leaves and medium-sized, oval, purple fruits. It was not spineless, but fairly early in bearing.

10. "*Jersey Belle.*" A large block of plants of this Station sort of eggplant was grown the present season. The record-book states that the 190 plants were noted for their vigor and early blooms. Two types of plants were distinguishable in the latter part of the season, the one being tall with purplish stems and leaves and inclining in these respects to the "Long Purple" parent, and the other medium tall with less purple in the stems and foliage and thus favoring the other parent, the "New York Improved." The first fruits were picked for the table July 10th, and the first picking of fifty mature specimens for seeding was made early in August. All the plants bear the same long, bell-shaped fruits of a rich purple color. All the plants are somewhat spiny.

11. "*Long White.*" This is a tall, broad, green-leaved sort, the fruits of which are medium long, early and fairly productive of greenish-white fruits that are as palatable as the purple sorts, but less attractive in the market.

12. "*Long Purple.*" This variety differs very little from the last, excepting in the purple color of stem and fruit and a darker green foliage. It is fairly early.

13. "*Livingston's Mammoth Purple.*" This is in the group of the "medium tall plants," with green foliage and large, oval, purple fruits. It was not productive, as the record in the preceding table shows.

14. "*Fordhook Improved.*" The seed of this sort failed.

15. "*Mammoth Pearl.*" Of the "medium tall" group, with light green foliage and large, oval, white fruits that were late in maturing. The leaves are more deeply lobed than in other sorts. There were but few specimens.

16. "*New White Pearl.*" This resembles No. 15, with somewhat larger plants and fruits. The latter showed a tendency to turn yellow upon maturing, in this approaching the "Black Snake" and the "Dwarfs."

17. "*New Excelsior Tree.*" This is, as its name suggests, one of the tall group, with long, spreading branches, bearing light green foliage and oval fruits of medium size, and of a light purple color. It is a late and somewhat spiny sort. It is near to No. 7.

18. "*New York Improved.*" A member of the "medium tall" group, with light green foliage and good-sized, oval, purple fruits. It is medium early and spiny.

19. "*New York Improved Purple.*" This seems to be the same as No. 18.

20. "*Pride of Sunnyside.*" This is not easily distinguished from the last two, alongside of which it was grown.

21. "*Striped.*" This is a variety characterized by its very white fruits, with the flesh nearly of the whiteness of the snow-apple. The plants are medium tall, with close, upright habit of growth, foliage light green and the fruits long, not large, and without more than the slightest indication of stripes. It is quite spiny.

22. "*Purple Perfection.*" This did not differ materially from the "New York Improved" group. There were but few plants and those made an indifferent record.

23. "*Thornless Purple.*" This is a tall sort, much like No. 7, but the fruits differ in the red-purple color. It was slow growing and among the late kinds, with spines plentiful.

24. "*New White.*" This agreed in all points with No. 15, with fewer spines and the fruits perhaps more slender.

25. "*Scarlet Chinese.*" This is added here because it is being bred with the ordinary eggplants. It is a very distinct species and treated elsewhere under the head of its hybrids. The plants are tall, woody and very spiny. The fruits are produced in great numbers and are of such a durable nature that a string of them hung in the greenhouse throughout the past winter reminded one of red peppers, although the shape is flat and more like some tomatoes.

Cross of "Long White" upon "New York Improved."

A block of thirty plants, representing the third generation of the cross of the "Long White" upon "New York Improved" ($\frac{11}{18}$), gave a great variety of plants. They were all of medium size, with the foliage light green and the leaves broad. Generally they fruited early, but some individuals were quite late in coming into bearing.

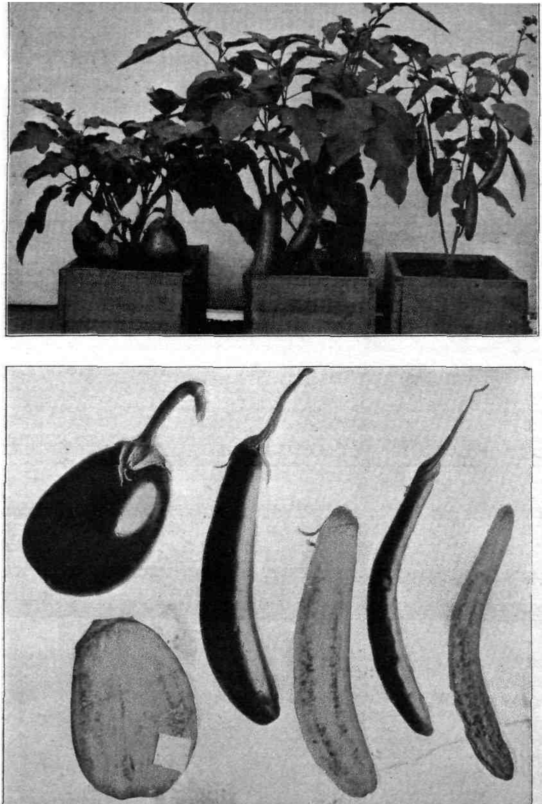


PLATE IX.

Crossed Eggplants The male parent plant, "New York Improved," is shown in the box upon the left, and the mother, "Black Snake," upon the right, while the cross is placed between them. The same arrangement of the three sets of fruits is shown in the lower portion of the plate.

As a rule, the fruits were well shaped—that is, oval or medium long—and varied from white to dark purple. In color several were quite objectionable. This variability is not unexpected, when one parent is white and the other purple in color of fruit. There were some very thrifty plants, with almost grass-green fruits, while others had the green and purple so combined as to produce a blotched and streaked appearance not preferred in the market.

Seeds were saved from only two of the plants and these were exceptionally fine in many respects, and agreed in having the many fruits—one seven and the other nine—of a delicate pink color when ready for the market. In shape they were somewhat thicker and shorter than those of the "Long Purple" variety, and altogether very acceptable. The usually firm flesh is of a fine white, resembling that of a snow-apple, and found nowhere else, in our experience, outside of the "Striped" variety listed as No. 21. In other words, the two plants selected show some distinctive characters that it is hoped may become fixed.

Cross of "New York Improved" upon "Black Snake."

A block of sixty plants of the cross of the "New York Improved" upon "Black Snake" $(\frac{18}{2})$ gave a very even lot of eggplants. The plants were usually very tall, with purple stems and leaves, in this respect resembling the mother parent, and bore a large crop of fruits through a long season. For the sake of a picture, a plant of each parent and one of the cross were placed in boxes in midseason, and after a few days, and the wilting had been overcome, they were photographed, as shown in the upper half of Plate IX. The male parent, "New York Improved," is upon the left; the mother, "Black Snake," upon the right, and the cross stands between. As these were average plants and all of the same age, something of the resemblances and differences may be distinguished. The fruits were quite uniformly long, with the sides nearly parallel, suggesting unusually large-sized window weights, average ones measuring ten inches long by three and a half inches in diameter. The tall, stiff stems of the plants enabled these long fruits to be held, as a rule, free from the ground, and when touching it was only by the end, thus helping to keep them from the decay that attacks large eggplants lying upon the earth through nearly their whole growth. Many of the fruits are curved somewhat, a characteristic that comes naturally from the "Black Snake" parent.

Crossed eggplants have, with us, always shown a remarkable vigor, and this instance is a striking application of the rule. The block showed so many good qualities in strength of plant and fruitfulness, and with all so uniform in fruit characteristics, that a considerable quantity of seed was saved from the best plants, which will be distributed under the record number 18 x 2 (Station Eggplant No. 1), that its merits may be tested by those who grow this kind of vegetable for profit as well as home use.

Something of the nature of the fruit of this cross is shown in the lower part of Plate IX. There a young fruit is shown, surface view and in section, in the middle of the picture, and the male parent upon the left and the mother upon its right-hand. It escapes the objectionable feature of both parents by being enough larger than the "Black Snake" and smaller than the "New York Improved" to make *good-sized slices and many of them. It is to be remembered* that the "Black Snake" is an early and profuse bearer, holding on in our climate until the frosts cut down the plants, but the fruits are too slender to be acceptable in the market. The cross in question brings up the size of the fruit and makes them of a convenient shape for cooking without any apparent loss of vigor and fruitfulness of the plant. The mother variety has the calyx strongly purple, with the flesh of the fruit beneath its lobes colored green. The fruits, in maturing, turn of a straw-yellow shade. These qualities the cross has in some instances and not in others, a point perhaps without practical value, but of interest in the breeding of this vegetable.

The breeding together of the two varieties in question seems to show that the "Black Snake" dominates over the "New York Improved." This is shown in an emphatic manner in the matter of spines. The male parent is a spiny sort, while these objectionable points are absent from the "Black Snake." No spines have been found upon the cross, and the writer has frequently drawn its foliage through the hands and rubbed the calyx and fruit stalk without feeling the least discomfort. It seems quite evident that the cross, when *fixed, will be a commercial sort that is truly spineless, a fact not met* with in any of the large-fruited varieties that have been grown in the Gardens.

The cross in question is not a mammoth "Black Snake," as might be inferred from the above, for the "New York Improved" has imparted a good share of its qualities, easily seen, for example, in the

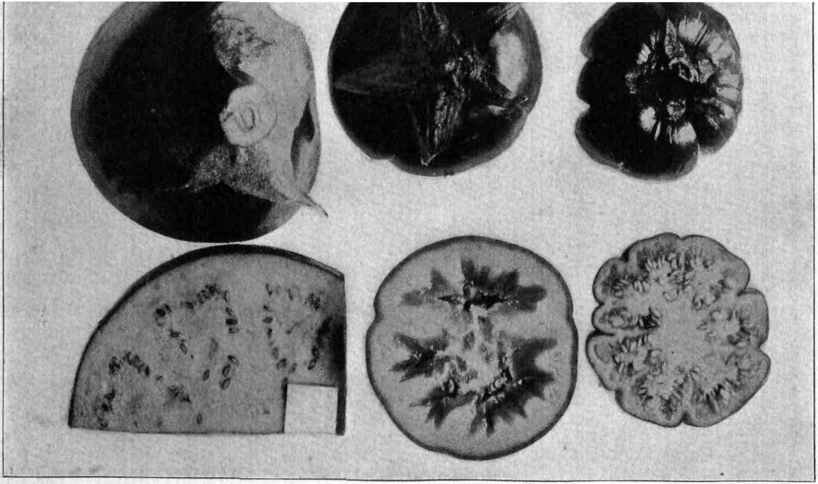


PLATE X.

Hybrid Eggplants. Fruit of the male parent (ordinary Eggplant) is shown upon the left, and the mother ("Scarlet Chinese") upon the right with the hybrid between them. The card is a half inch square.

foliage. It is possible that it may bear the name abroad that it is known by in the Gardens, namely, the "Longfellow," but the seed will go out under the cross record 18 x 2, or Station Eggplant No. 1.

A Hybrid Eggplant.

During 1904 a fruit was obtained upon a "Scarlet Chinese" eggplant (*Solanum integrifolium* Poir.) after treatment with pollen from one of the common garden varieties of eggplant, the "Fordhook Improved" (*Solanum Melongena* L.) ($\frac{14}{25}$). As a result, one seed grew and produced a plant that has shown itself to be an unmistakable hybrid between these species. The *Solanum integrifolium* is a tall-growing bush, with comparatively smooth, deeply-lobed leaves, armed upon both sides of the vines with stout, sharp spines and small flowers, in clusters, that produce numerous small, flat fruits, with prominent lobes and of a bright, scarlet color. The fruits are so durable that they may be strung, like peppers, and kept for many months. It is on account of these bright, shiny fruits that this species, probably from Africa, has long been grown for ornament. The contrast with the ordinary edible eggplant species is quite marked.

The hybrid plant in question was unusually thrifty from the start, and during the last half of the season exhibited a broad top, several feet across, and continually loaded with a hundred or more of blooms, midway in size between the two species involved in the union. The plant in other ways differs from the parents, as, for example, the handsome, purplish leaves are near to the "Chinese" in outline, combined with the soft texture of the "Fordhook," and abounding in spines, those upon the stems resembling the prickles of rose canes.

While the plant produced a great display of flowers, the setting of fruit was the exception, and it was the 1st of October before a single mature fruit was secured. This was with three shallow grooves, somewhat flat, a bright orange and about two and a half inches in its greater diameter. This specimen was cut in halves and photographed, both in surface and interior view, along with corresponding views of fruits of both parents, as shown in Plate X.[1] It is to be observed that the fruit is larger than the "Chinese," shown upon the right, and there is only a slight suggestion of its deep grooves. The calyx

[1] As all the "Fordhook" seed failed this season, the male is represented in the picture by a fruit of "New York Improved," which has all the essential characters, for this purpose, of the "Fordhook."

is in size and texture nearly midway between the two species. Within the differences are greater, for here the firm flesh is seen to be quite thick, resembling neither parent in texture. That there were only thirty-nine seeds may have something to do with the appearance of the slice, and other fruits may show a modification here. While it indicates that it may have good keeping qualities, there is little in the substance of the fruit to suggest much economic value.

The plant grew without stint until the hard frosts of November put an end to the life of the hybrid plant. In midsummer, seeing that it would fruit but very sparingly if left to itself, many blossoms were served with pollen from the esculent sorts, as well as from the "Chinese" species, and at the close of the season there were many fruits of full size and some ripe enough for seed.

In a few words, this hybrid shows remarkable vigor, growing to perhaps three times the size of its parents, with a great tendency to produce blooms, which quickly fall away. It behaved like a perennial and did not find time in an unusually long season to mature more than two dozen fruits. The chief hope with this hybrid, from an economic standpoint, is to breed it to the *Solanum Melongena,* with the thought of making it productive of good-sized fruits, having a fine, firm flesh, that will bear transportation well and resist decay much longer than our present type of eggplants.

EXPERIMENTS WITH SUMMER SQUASHES.

The work with summer squashes was continued during the year, and the subjects in hand are shown in their combinations in the following table. Each variety has a numeral assigned to it, and the method of union is known by the position of the numbers. The key to the varieties is as follows:

No. 5. "Yellow Crookneck." The common type of warty squash.
" 6. "Long Island Scallop." A cream-colored, smooth squash.
" 8. "Early Bush." A cream-white, smooth scallop."
" 9. "Golden Bush." A solid yellow, smooth "scallop."
" 10. "Mammoth White Scallop." A cream-white fruit.
" 11. "Strickler's Summer." An orange-colored, warty "crookneck."
" 12. "Silver Custard." A deep, somewhat ribbed, cream-white "scallop."
" 13. "Giant Summer." A long, "straightneck," with few warts.

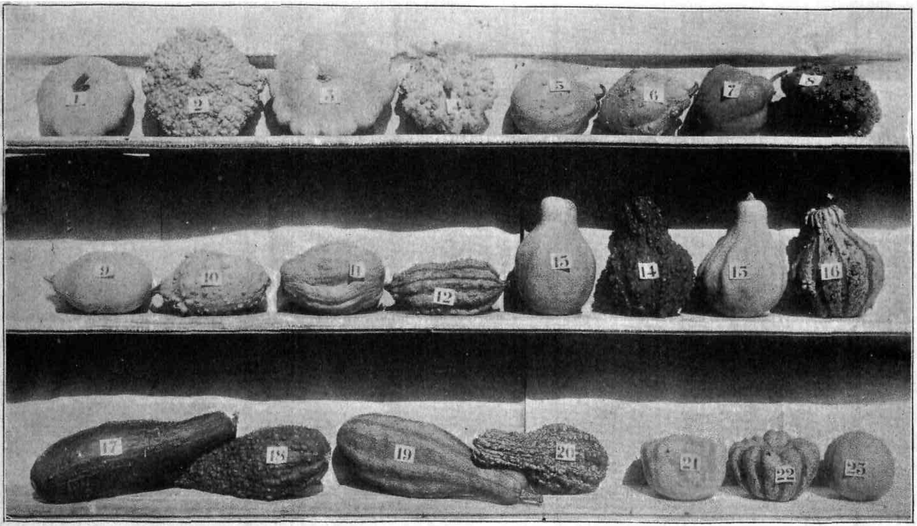


PLATE XI.

Types of Summer Squashes from among the crosses. The numbers upon the fruits correspond to those in the table of types. From 1 to 4 are flat; 5 to 8 rectangular; 9 to 12 oval; 13 to 16 "Jug"; 17 to 20 long-neck; 21 to 22 "Cheese," and 23 spherical.

In the scheme that follows, the crosses are arranged to the first figure in the combination—that is, all with 5 precede those with a higher initial number. Thus, IX. 5 (6 x 5) 5 (6 x 5) indicates that the combinations are as follows: Six was crossed upon 5—that is, "Scallop" upon "Crookneck"—and the next year after 5 was crossed upon this cross (6 x 5), giving a three-quarter blood of the "Crookneck" to one-quarter of the "Scallop," and the present year a cross of the two crosses has been grown as No. IX. of the series of crosses. In other words, a cross of "Crookneck" ("Scallop" upon "Crookneck") was bred to its own cross last year, and plants of this combination were grown this season.

Thirty-three crosses of summer squashes secured in 1903 or 1904 were grown the present season. The Roman numerals stand for the rows which extended across the plot. Each row, of nine hills, was planted with seed from the same fruit, and the nature of the cross is indicated in the second column, and a key to the record figures is given below. Some of the facts obtained as to vines and fruits are condensed into the following tabular form. The record was made early in the season, and therefore upon the first fruits. Later on the number of fruits increased many times, but the fruits of any particular vine do not vary materially:

Row number.	The cross.	Number of vines.	COLOR OF VINES. Light green.	Dark green.	COLOR OF FRUIT. Cream.	Yellow.	Striped.	Other.	SHAPE OF FRUIT. Flat.	"Jug."	Longneck.	Wartiness.
I.	5x6	17	......	......	8	5	Much.	....	2	21	......	Little.
II.	5x9	18	......	......	8	18	Little.	......	18	3	.....	Very little.
III.	5x10	22	......	.....	22	.....	None.	.....	22	.....	......	Little.
IV.	5x12	16	......	......	5	11	Little.	......	5	11	.....	None.
V.	5 (5x6)	21	5	16	......	20	Much.	......	15	5	.....	Little.
VI.	5 (6x5)	27	8	19	14	14	Little.	......	13	15	.....	None.
VII.	(5x6) (6x5)	30	12	18	7	20	Little.	3	14	16	1	Little.
VIII.	(5x6) 5 (6x5)	27	11	16	12	9	Much.	6	7	20	....	Little.
IX.	5 (6x5) 5 (6x5)	24	13	11	16	3	Little.	5	8	15	......	Little.
X.	(5x6) 11	16	4	12	5	11	Much.	.....	4	10	2	Much.
XI.	6x5	20	16	4	21	......	None.	.....	9	12	......	Little.
XII.	6x9	31	19	12	30	.....	None.	......	30	......	.....	Very little.
XIII.	6 (5x6)	....	6	11	7	8	None.	2	7	9	1	Very little.
XIV.	6 (6x5)	27	20	7	28	1	None.	.....	15	14	......	None.
XV.	(6x5) (5x6)	27	22	5	28	.....	Much.	2	21	7	......	Little.
XVI.	(6x5) (6x5)	26	14	12	16	6	Little.	1	11	12	......	Very little.
XVII.	(6x5) 11	15	7	8	17	16	Little.	.....	......	26	7	Much.
XVIII.	8x5	11	11	.....	10	......	None.	.....	10	.....	.....	Little.
XIX.	8 (5x6)	16	12	4	17	......	None.	......	14	3	......	Little.
XX.	8x12	13	10	3	14	.....	None.	....	14	.....	......	Little.
XXI.	9 (6x5)	21	5	16	4	17	Much.	......	17	4	.....	Little.
XXII.	10x11	29	29	......	26	3	None.	.....	14	15	......	Little.
XXIII.	Failed.	....	....	......	.....	.....	....	......	.....	....	......	....
XXIV.	10 (6x5)	17	17	.....	16	....	None.	......	18	8	......	Little.
XXV.	11x5	23	......	23	.....	23	None.	......	......	......	23	Much.
XXVI.	11x9	22	....	22	.....	22	None.	.....	.....	22	......	Little.
XXVII.	11x10	24	24	.....	24	......	None.	....	......	24	......	Much.
XXVIII.	11 (5x6)	23	7	16	5	20	Much.	....	4	17	4	Much.
XXIX.	11 (6x5)	24	9	15	7	17	None.	....	2	9	13	Much.
XXX.	12x9	20	17	3	20	......	None.	.....	20	.....	......	Little.
XXXI.	12x11	25	10	15	10	14	None.	.....	3	21	......	Much.
XXXII.	12 (5x6)	24	16	8	17	3	Little.	4	15	9	.....	Much.
XXXIII.	12 (6x5)	23	19	4	31	......	None.	.....	15	16	.....	Little.
XXXIV.	13x11	24	......	24	......	24	None.	....	......	......	24	Much.

The color of the vines was overlooked for the first four numbers. It is observed that the color of the vine is associated with that of the fruits—that is, for example, the light green of the plant is connected with the cream-colored fruit, and, contrarywise, the dark green with the yellow, with exceptions in many cases. Some rows are all light green and have only cream-colored fruits; others all dark green and yellow-fruited. The rows carrying the cream-colored fruits show very little stripes, while those with much yellow are more inclined to have the stripes and to be long, or not flat. Thus the last row (XXXIV.) had all its twenty-four vines dark green, yellow-fruited, long neck and warty, and row XXVI. had its twenty-four vines all light green, cream-fruited, jug-shaped and warty. These results were as anticipated, for the parents are much alike in each pair. It is among the crosses of the "Scallop" and "Longneck" that the association of leaf and fruit color is most interesting.

Mr. Owen, during the season, made a vast number of pollinations among these crosses. At first suitable paper bags were employed in covering the male and the female flowers upon the afternoon of the day previous to their opening. This method had its disadvantages, and for a time strings (wire labels) were used instead. This method consisted in simply twisting the wire closely around the unopened corolla toward nightfall to prevent the entrance of insects during the few hours in the early morning, before the flowers could be hand-pollinated. It was found that small insects would sometimes force themselves through the folds of the corolla, and for perfect safety the bags, while less convenient, were again resorted to. The pollination was made under the following rules: (1) Always pollinate within the cross and either (2) between two plants with the same type of fruit or (3) within the same plant. By planting the mature seeds from a score of fruits secured by hand-working within the plant, it was found that such seeds were viable. After this the pollination was usually made between the two kinds of flowers upon the same plant. In this manner a large stock of seed has been secured, by means of which it is hoped to finally obtain plants that will reproduce their kind as perfectly as the ordinary commercial types of squashes. The stability of form of the latter is largely a matter of keeping the seed pure, and this is difficult and almost beyond the hope of the ordinary grower unless the plantings are isolated and limited to one sort or the flowers are purposely hand-worked for the necessary seed for the next season's use.

Second Crop of Summer Squashes.

Many fruits were obtained among the crossed squashes by phyto-fertilization—that is, within the same plant—and seeds from these were planted in July and early August as a test of the vigor of plants thus produced, and to determine something of the range of variation in such sets of plants of identical parentage. A few of the resulting fruits grew to marketable size, but the majority were small, and the shape at maturity is somewhat a matter of inference.

There were eight rows, of four hills each, that gave the following results:

Row.	Color and Shape.	Number of Sizable Fruits.	Remarks.
1	Cream, scallop	2	Very nearly true to parent.
2	Cream, "jug"	3	" " " " "
3	Striped, dark and light green	2	" " " " "
4	White, scallop	1	" " " " "
5	Cream, "jug"	3	" " " " "
6	Pink, warty "jug"	5	Quite variable.
7	Deep scallop	4	Very nearly true to parent.
8	Yellow, rectangular	3	" " " " "

There seems to be hope of fixing the desired types through fertilization within the plant.

Types of Summer Squashes.

During the present season the two plots filled with crosses of summer squashes gave an opportunity to formulate a preliminary classification of this group of vegetables. It is founded entirely upon the shape and surface characters of the fruits, and therefore each type may be further subdivided upon the basis of color or other qualities.

The classification assumes that the flat, smooth, unscalloped fruit is the simplest general type of squash, and the long, warty and fluted one the most complex.

Type.
1. Flat, smooth, not scalloped.
2. " " scalloped.
3. " warty, not scalloped.
4. " " scalloped.
5. Rectangular, smooth not scalloped.
6. " " scalloped.
7. " warty, not scalloped.
8. " " scalloped.
9. Oval, smooth, not fluted.
10. " " fluted.
11. " warty, not fluted.
12. " " fluted.

Type.
13. "Jug," smooth, not fluted.
14. " " fluted.
15. " warty, not fluted.
16. " " fluted.
17. Longneck, smooth, not fluted.
18. " " fluted.
19. " warty, not fluted.
20. " " fluted.
21. "Cheese," smooth, not fluted.
22. " " fluted.
23. Spherical, smooth, not fluted.

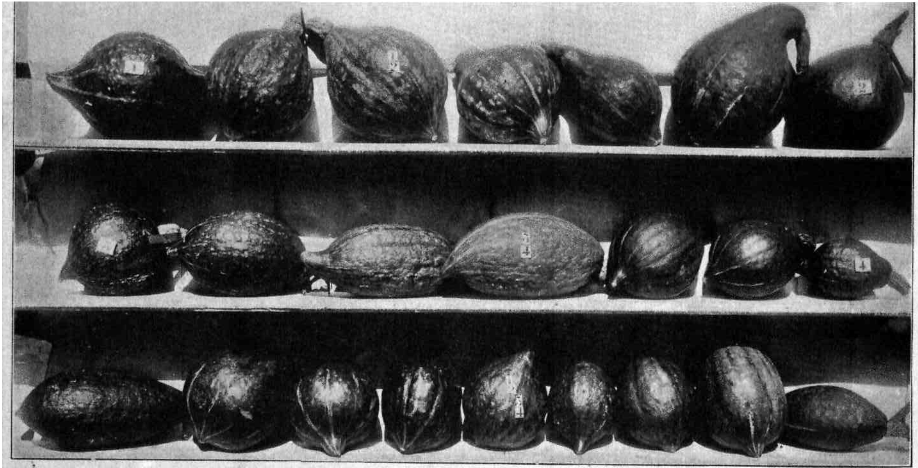


PLATE XII.

Crosses of Winter Squashes. The top row shows the parents "Hubbard" (1) and "Boston Marrow" (2) at the ends, and their crosses (½) between them. In the same manner "3" and "4" are given in the second row, while the double crosses ½ upon ¾ are shown below.

These types are given in the above order, with corresponding numerals, in Plate XI. The "Cheese" forms (Nos. 21 and 22) naturally come in between "rectangular" and "oval" types, and the "spherical" (No. 23) is just before the "ovals," also, but, not having specimens to show the lacking forms in the theoretical scheme for these general types, the ones at hand were added at the end.

EXPERIMENTS WITH WINTER SQUASHES.

In 1903 crosses were secured between the "Hubbard" upon "Boston Marrow" and "Delicious" upon "Golden Hubbard," but during last year only one fruit was obtained from these crosses, namely, of the "Delicious-Golden Hubbard," and this had been pollinated with the other cross above named—that is, the seeds carried the "blood" of four varieties.

It is with much difficulty that winter squashes, particularly of the "Hubbard" group, can be grown, on account of the swarms of beetles that attack the seedlings and the grub that afterward works in the base of the stem of any that survive the striped "bug." Beside these insect enemies there is a wilt disease, more or less in evidence, so that it is necessary to plant very liberally to insure a small stand of plants. During the present year it was only through a second planting and daily attention that fruits were secured of the above crosses.

About twenty fruits were obtained of the "Hubbard" upon the "Boston Marrow" cross, and samples of these are shown in the upper row of Plate XII. The squash to the left, marked "1," is a fair specimen of the "Hubbard" or male parent, and the mother ("Boston Marrow"), marked "2," is shown in a small fruit at the right end, while the crosses, one of them marked "½," lie between. As a rule, the shape more nearly resembles the male, while in color there are strong indications of the cross. Nearly all of the fruits were of a pale or "pea" green, with the cream color showing in more or less well-defined streaks. In some instances the fruits were more cream orange than green, and none of them was of the solid olive green characteristic of the "Hubbard." Two large fruits of nearly the same general shape, but one green and the other yellow, were grown upon the same plant. It was generally true that the fruits of the same vine were not duplicates in appearances. At the time of writing it is too soon after the harvest to give full details of the internal

characteristics or pronounce upon the keeping qualities of the crosses. All the fruits that thus far have been tested were of superior quality for table use. The somewhat striped pea green and cream orange surface of the cross is particularly attractive, and, judging from the yield under the very trying circumstances of the past season, it is to be expected that this "Hubbard-Marrow" will prove of value. Considerable seed has been saved for testing among the truck-growers of the State.

The cross between the "Delicious" and "Golden Hubbard" is shown in a row of five fruits upon the middle shelf in Plate XII. The male parent is shown at the left, marked "3," and the mother to the right, marked "4." This last is quite under size. The "Delicious" is a solid olive or "bronze" green, somewhat like the "Hubbard," but without any neck at the stem end, and therefore more nearly round and usually somewhat smaller than the last named. The "Golden Hubbard" is fairly well described in the name, and is a variety bearing a medium-sized and long cream orange fruit. It is seen that the crosses produced fruits that resembled the mother in length, some of them being quite long, and varied in color from a solid olive green, like the "Delicious," to a cream orange, like the "Golden Hubbard," while some were a striped mixture of the two. Here, again, it is too soon to describe the table and other qualities of these crosses.

The lower row of fruits in Plate XII. are all from plants that resulted from a combination of four of the above-mentioned varieties, and they show quite a range of variation. It is impossible to conclude, with so few specimens, what may come of this double cross.

All of the three sets were pollinated within the cross, so that the same crosses may be continued for further study.

The crosses among winter squashes gave vines in vigor, barring the severe experience they had with the beetles and extreme drought in the early part of the season. After the rains came, in August, the surviving squash vines took on renewed life and made many fruits, only a small proportion of which came to maturity.

The "Hubbard-Boston Marrow," of which there were twelve hills, suffered much more than the summer squashes from the beetles. Any plant that chanced to be unprotected by the fine mosquito netting had upwards of a hundred of the pests upon it and was quickly destroyed. In addition to the insects and bad weather, these vines

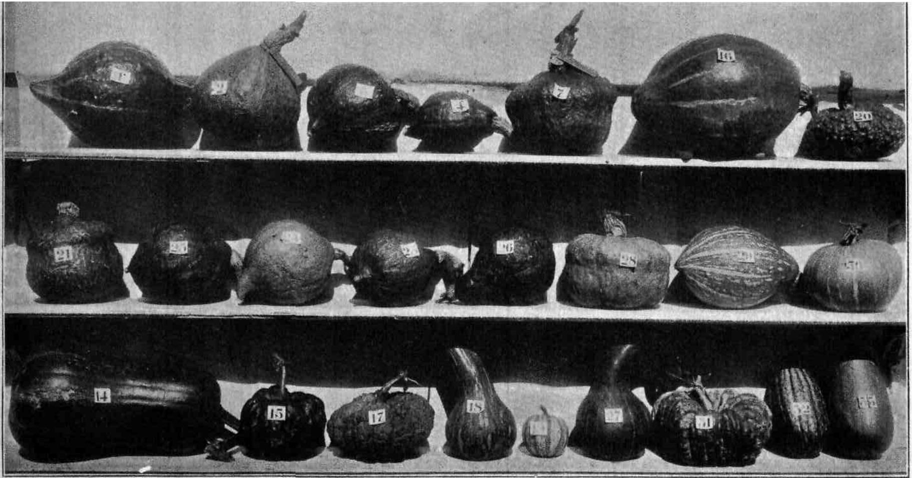


PLATE XIII.

A Set of Winter Squashes. The two upper rows show the fleshy-stemmed sorts, and those with hard stems are below. The record numbers upon the fruits correspond with those in the notes.

were badly attacked by the grub at the base of the stem and many were destroyed by it. The sole survivor of four hills, separated far from all the others, became a remarkably strong plant and yielded six large fruits. They show the mixture of the two parents in form and coloration of the fruits. They were quite uniformly of the shape shown at "½," in Plate XII., while the surface showed large blotches of a pale orange upon a background of pale, almost pea, green. Some of the orange blotches almost reach the length of the fruit and give the impression of long, irregular stripes. Both parents have affected the cross, and in no part of the surface is the original green of the "Hubbard" or orange of the "Boston Marrow" to be found.

Notes upon Varieties of Winter Squashes.

Quite a full list of the winter squashes was grown during the past season, and the following notes are here given in connection with the record numbers that have been assigned to each variety. The first four have been previously grown and considered in the reports. The numbers upon the fruits in Plate XIII. corresponded with those given below:

No. 1. "Hubbard." This is an old variety, with a history that, according to Mr. Gregory * reaches back more than a hundred years, taking its name from one Hubbard, who brought it to the notice of the seed trade nearly fifty years ago. The fruit is medium large and keeps quite closely to a definite shape, namely, larger near the blossom end, to which it tapers rapidly to quite distinct and curved point. Toward the stem the tapering is nearly as rapid for a distance and then extends in a broad neck until the stout, fleshy stem is reached. The fruit is usually somewhat one-sided—that is, the curves are less upon the under side, which is also otherwise somewhat flattened. The surface is slightly rough, due to broad ridges that are somewhat uneven, which, together with the longitudinal creases, gives rise to a coarse, warty appearance in extreme cases. The whole surface is quite evenly of a dark green, varying toward olive yellow upon the under side and to bronze when fully mature. The flesh is thick, somewhat olive green near the outline and more orange toward the center. A large number of large, white, oval seeds are usually produced.

No. 2. "Boston Marrow" was introduced in 1831. This has a large fruit with a short blossom end and very obscured neck, so that the general outline is nearly broadly ovate, with the longer taper toward the stem end. The surface is nearly smooth, the ribs being very indistinct, and in color the orange is interrupted only slightly by flint strips of a lighter color, which follow the depressions from the blossom end back for a third or more of the fruit. The blossom tip sometimes remains green. The flesh, not thick, is orange throughout, of the same color as the

* "Squashes; How to Grow Them."

outside, and the seeds are large and white. The quality is not equal to that of the "Hubbard," but the variety is productive.

No. 3. "Delicious." The "Delicious," as before noted, has a smaller fruit than the "Hubbard," but resembles that standard sort in the solid olive or bronze green color. It has no neck at the stem end and in longitudinal view is long, egg-shaped, tapering nearly straight to the blossom end. The flesh is thick and of an olive orange color. During the present season this variety did better than any other, upon land that was too poor and dry for the "Hubbard" and "Boston Marrow." It is, in quality, high, and this, with the hardiness and productiveness, make this variety very desirable.

No. 4. "Golden Hubbard." This is a small-fruited, orange "Hubbard," with the squash long and somewhat grooved. The flesh is thick and quality good, but with us it has not been at all productive.

No. 7. "Warren." This is a "turban" of the "Essex Hybrid" type—in fact, is a recent offspring of it, quite productive of large, cheese-shaped, warty, orange-colored fruits. The turban feature at the blossom end of the fruit is a source of weakness, as here the flesh is folded peculiarly, which favors decay. The flesh, quite thick in the stem half of the fruit, is deep orange at the center and pale orange toward the exterior.

No. 14. "Giant Neapolitan." This is a strong vine, producing fruits of great size, some three feet long and frequently bent. It is of the slender-stemmed group and its quality is not desirable.

No. 15. "Japanese" (No. 12843, U. S. A. D.) is apparently the same as our No. 31, figured in Plate XIII.

No. 16. "Mammoth Chili." This has a very large fruit, quite variable in size, but in general oval, without ribs and decidedly netted, like muskmelons.

No. 17. "Japanese" (No. 12845, U. S. D. A.) Practically the same as No. 30. The specimen shown in Plate XIII. is quite warty.

No. 18. "Winter Crookneck." This is a slender or hard-stemmed squash, producing large, striped fruits, with long, much-curved, solid necks. The flesh is thin, of a bright, light orange, with the quality inferior.

No. 19. "Cocoanut." A small squash, its size and shape being suggested in the name. It exhibits many variations, but in general the shape is oval with a sunken stem end and a blunt, pointed blossom end and somewhat corrugated, and of a cream color, striped in the grooves with yellow. At the stem end there is a disc with sharply-defined border, in which the yellow stripes are replaced by green. This last variation may be elsewhere upon the fruit in blotches upon one side. The flesh is a light yellow, with a small seed cavity and bearing small, oval, straw-colored seeds. The stem is long and very slender.

No. 20. "Victor." Produces a flat, orange-colored fruit, of small size.

No. 21. "Bay State." Is a somewhat cheese-shaped fruit, with a bluish-green color.

No. 22. Duplicate.

No. 23. "Golden Bronze." This is a squash of the "Hubbard" type, but broader, with green veining and shallow ribs.

No. 24. "Marblehead" is closely related to the "Hubbard," with a bluish color and oval shape. The quality is superior.

No. 25. "Dunlap's Marrow." Yields a fruit of the "Marrow" type, oval and often strongly ribbed and a beautiful solid orange color, with the surface finely netted, somewhat in stripes. The flesh is fairly thick, of rich orange, same as the exterior and with seeds long and white.

No. 26. "Warted Hubbard" is the ordinary "Hubbard," with a rough exterior. There was great variation in this wartiness among all the "Hubbards."

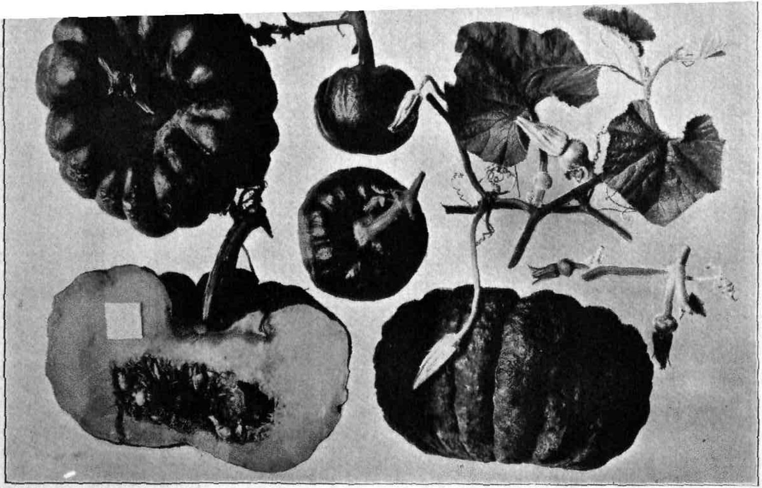


PLATE XIV.

A kind of Japanese Squash (31), No. 12844 U. S. D. A., is shown in various parts of vine, flower and fruit. The card upon the flesh surface is an inch square.

No. 27. "Canada Crookneck." As the name implies, the fruit has a long, crooked neck, like No. 18. When mature the fruits take on a dull cream color. The quality is not good.

No. 28. "Essex Hybrid," like "Warren" and "Bay State," is cheese-shaped and a turban, carrying the blood of the "Hubbard." The color is a cream pink and the fruit nearly smooth.

No. 29. "Butman." This produces a fruit of nearly the shape of the "Hubbard," but striped and netted light green upon a dark green background. Gregory states that this is a cross between the "Hubbard" and a Japanese variety. The flesh, of a light salmon color, is of high quality.

No. 30. "Faxon." The fruit is of a small type, flattish, nearly smooth, with no evident blossom tip, and the medium-sized stem sets upon the smooth upper end. In color it varies from cream orange to a light orange, with sometimes a darker orange showing through in fine streaks, especially at the blossom end. The flesh, comparatively thin, is a bright orange, and of the same thickness throughout the whole fruit. The white seeds are of medium size and shape.

No. 31. "Japanese" (No. 12844, U. S. D. A.) Four hills of this variety were grown upon the Gardens. (Plot 1, Series 1.) The vines showed unusual vigor and in time covered the whole ground and ran into the surrounding territory. From the start the character of the vine was quickly seen to differ from any of the American sorts grown elsewhere upon the gardens and new land. The leaf was angular, like the cucumber, and of medium size; the flowers, produced in profusion, were the largest of any sort under experimentation. They differ also in having the calyx, with long, slender or spatulate lobes (five and more) sometimes three inches long. The parts of the andnecium and gynæceum are more open than is usual in squashes and some flowers were with both sexes. These plants were not very fruitful, there being eight specimens, none of them over one foot across. The fruits are flat, deeply corrugated, with a glaucus green surface when mature. The flesh is a lively orange and quite thick, leaving only a small seed cavity and stringy placenta, somewhat like the field pumpkins in this last feature. The stem is long and slender and deeply set in the scalloped upper side of the fruit.

Plate XIV. shows a tip of a vine, with the leaves, and male and female flowers, also young squashes, which are nearly smooth and livid green, and mature fruits in three views. The card upon the cut flesh is an inch square, from which the size of the squash may be judged. The fruit is neither prolific nor handsome, and its quality is only fair. Several crosses were obtained between it and other vine and bush squashes. It is much less a favorite with the striped beetles than the "Hubbard" group, and no vines were troubled with other pests.

32. "Delicata." This variety is strongly marked by having the fruits small, oval, pointed, fluted, striped green and yellow and more or less mottled. The flesh is thick, orange-colored and of fine quality.

33. "Dauphne Pumpkin." This variety has a strong, running vine, but produced with us only a small number of small, oval, yellow, smooth fruits.

EXPERIMENTS WITH SALSIFY.

In order to study the colors of the flowers, the twelve rows were divided, by tall stakes, into sections of five plants each, and a record made for each plant. The following chart is for the first fifty plants. When the plants failed to bloom or to produce flowers that were normal, the space is left blank. The abbreviation "alb." indicates that the plant was an albino, and "y" indicates that the central flowers of the head were yellow. The "Prang Standard Scheme" was used.

Color Chart of Hybrid Salsify (Plot 3, Series VI.)

Plant. Row:	1	2	3	4	5	6	7	8	9	10	11	12
1	31	91	81y	93	333y	..	..	..	..	334	93	..
2	..	333	224	93	41	333y	233	..	21	12	93	234
3	253y	..	233	41y	234	83	..	..	83	..	93	93
4	..	93	333y	93	31y	..	..	..	..	..	..	93
5	333	234y	93	..	93	93	224	93	..	..	224	93
6	234y	253y	..	93	..	325	333y	61y	..	..	224	41
7	253y	224	223	21y	..	41y	..	234	..	..	..	31
8	93	61y	385	242	..	21y	..	333	325	..	21y	355
9	93	224	41y	94	93	333	..	334	93	..	..	333
10	95	93	..	242y	225	333	31	..	242y	234	93	41
11	333	..	333	234	41y	93	93	..	242y	333	..	92
12	..	224	224	..	41y	..	333y	325	385	..	234	333
13	93	224	233y	..	234	..	31	93	93	333	..	234
14	93	93	93	333	..	234	224	93	93	333	..	93
15	33y	334	..	255y	234	..	93	224	93	93	93	234
16	224	233y	95	21y	333y	225y	..	93	..	..	..	234
17	..	333	41y	95	93	84	93	..	..	21	41y	234
18	..	234	..	93	alb.	93	224	224	41y	..	333y	93
19	..	93	94	233	224	93	41y	..	333	..	..	..
20	31	82y	93	41y	..	234	..	..	..	225	..	234
21	12	..	..	21y	93	234	..	93	..	..	21	41
22	..	93	233	205	233	..	21	alb.	21	alb.	224	234
23	..	375	..	234	41y	..	325	333	82y	93	..	..
24	..	72	224	93	93	31	224y	..	..	..	93	92
25	333	21	224y	93	93	..	93	..	..	225	234	..
26	93	333	224y	233	93	333	41	93	93	41y	..	..
27	..	..	93	93	224y	..	..	253	..	234	234	255
28	..	..	93	242	93	93	234	..	224	41y	93	93
29	..	233y	12	alb.	..	..	..	..	alb.	..	385	..
30	..	333	242	93	334y	333	224	..	224	..	234	234
31	223	94	225	..	..	93	93	234y	alb.	..	..	21
32	93	21y	334	..	234y	233	..	..	12	234	93	234
33	223	224y	334y	82y	41y	242y	..	93	..	93	61	333
34	..	233	333	21y	31	93	333	333	41y	..	385	333
35	224	224	..	233	93	333	..	333y	..	234	234	234
36	41y	222	234	223y	93	93	31	31y	93	..	alb.	12
37	254	95	234	..	233y	31y	93	..	233	333	93	234
38	93	234	alb.	..	..	41y	333	..	..	31	21	93
39	93	234	333y	..	93	333	93	333	234	31	21	234
40	242y	alb.	..	12	333y	93	93	224	..	225	234	12
41	93	333	41y	234	21y	..	93	93	..	333	224	31
42	225	93	93	93	21y	234	..	233	..	334	..	..
43	93	..	333	333	243	93	93	234	333	..	224	..
44	253	224y	12	242	..	234	243	21	..	..	..	93
45	226	333y	242	224	..	93	95	93	..	..	31	93
46	93	92y	333y	85y	41y	224	..	93	..	234	224	234
47	93	[illegible]	242y	..	93	224	..	234	234	234	325	225
48	12	224y	93	93	21	41y	..	385	93	234	..	234
49	41	234y	alb.	242	234	333y	..	..	21	..	93	41y
50	91	234	234	41y	31	31y	..	234	93	..	234	41y

From the above table the following summary of colors is drawn:

	12.	Dark red	9
	21.	Dark red red orange	11
	21.	" " " " (yellow center)	10
	31.	Darker red orange	13
	31.	" " " (yellow)	4
	33.	Red orange (yellow)	1
	41.	Darker orange red orange	6
	41.	" " " " (yellow)	23
	61.	Darker orange yellow orange	1
	61.	" " " " (yellow)	2
	72.	Dark yellow orange	1
	81.	Darker yellow yellow orange	2
	82.	Dark yellow yellow orange (yellow)	3
	84.	Light yellow yellow orange	1
	85.	*Lighter yellow yellow orange*	1
	91.	Darker yellow	2
	92.	Dark yellow	2
	92.	" " (yellow)	1
Parent	93.	Yellow	109
	94.	Light yellow	3
	95.	Lighter yellow	5
	205.	Lighter violet blue violet	1
	222.	Dark violet red violet	1
	223.	Violet red violet	3
	223.	" " " (yellow)	1
Parent	224.	Light violet red violet	28
	224.	" " " " (yellow)	7
	225.	Lighter violet red violet	7
	225.	" " " " (yellow)	1
	233.	Red violet	12
	233.	" " (yellow)	3
	234.	Light red violet	49
	234.	" " " (yellow)	4
	242.	Dark red violet	6
	242.	" " " (yellow)	6
	243.	Red red violet	2
	253.	Orange gray (brown)	1
	255.	Lighter orange gray	1
	255.	" " " (yellow)	1
	325.	Lighter gray	5
	333.	Red gray (russet)	34
	333.	" " " (yellow)	14
	334.	Light red gray	6
	334.	" " " (yellow)	3
	353.	Yellow gray (citrine)	1
	353.	" " " (yellow)	3
	354.	Light yellow gray	1
	355.	Lighter yellow gray	1
	375.	Lighter blue gray (slate)	1
	384.	Light violet gray (heliotrope)	1
	385.	Lighter violet gray	4

It is seen that the number most in evidence is 93, the wild yellow parent, and the next is No. 234, followed by No. 333, and the cultivated violet parent type is fourth.

Salsify in the Old Plot.

Hybrid salsify has been left to take care of itself for five years upon one half-plot of the Experiment area.

During the present year the record for the colors and the number of plants for each color or shade is as follows:

No.	12. Dark red	5
"	12. " " yellow	4
"	21. Darker red red orange	4
"	21. " " " " yellow	4
"	31. Darker red orange	8
"	31. " " " yellow	12
"	32. Dark red orange	1
"	41. Darker orange red orange	2
"	41. " " " " yellow	11
"	51. Darker orange	1
"	51. " " yellow	3
"	82. Dark yellow yellow orange yellow	2
"	83. Yellow yellow orange yellow	1
"	91. Darker orange	1
"	91. " " yellow	3
"	93. (Parent) Yellow	220
"	94. Light yellow	19
"	95. Lighter yellow	1
"	224. (Parent) Light violet red violet	12
"	224. Light violet red violet	9
"	225. Lighter violet red violet yellow	1
"	253. Orange gray yellow	1
"	333. Red gray	39
"	333. " " yellow	46
"	335. Lighter red gray	1
"	335. " " " yellow	2
"	354. Light yellow gray	1
"	354. " " " yellow	2
"	355. Lighter yellow gray yellow center	1

It is seen that out of 417 plants recorded in the area, 220, or a little more than half, are of the type of the yellow parent—that is, the wild species (*Tragopogon pratensis* L.)—while less than one-tenth as many were of the color of the cultivated species (*T. porrifolius* L.) The reason for this may reside in the greater seeding capacity and vitality of the yellow type.

It is to be noted that the number of those heads with yellow centered flowers—the ray blossoms having some other color—is very large, so that all together the yellow color is by far the leading one for the heads that are not yellow throughout.

At the time (June 14th) when the plants were maturing the seeds, a number of heads, one from a plant, gathered at random, gave the following results, in terms, of good and abortive fruits (seeds):

No.		Sound.	Abortive.
12.	Dark red	7	63
12.	" " (yellow)	1	74
21.	Dark red red orange (yellow)	21	19
21.	" " " " "	22	32
31.	Dark red orange (yellow)	26	34
31.	" " " "	42	19
31.	" " " "	8	49
41.	Darker orange red orange (yellow)	26	42
41.	" " " " "	10	52
41.	" " " " "	15	37
82.	Dark yellow yellow orange (yellow)	26	42
82.	" " " " "	6	43
93.	Yellow (average of eighteen)	42	17
224.	Light violet red violet	46	10
224.	" " " "	47	11
224.	" " " " (yellow)	13	58
224.	" " " " "	13	30
224.	" " " " "	12	41
234.	Light red violet (yellow) (average of eight)	11	44
255.	Lighter orange gray (yellow)	4	48
333.	Red gray	10	59
333.	" " (yellow)	13	37
333.	" " "	14	59
333.	" " "	9	52
333.	" " "	25	25

It is noted that the number 93 leads with twelve, while No. 234(y) comes next, with eight. A striking difference between these two sets is seen in the number of sound and abortive seeds. The 93 gives an average of 42 sound and 17 abortive seeds, while 234(y) has 11 sound and 44 abortive seeds.

At another time all the heads upon five plants were considered, with the following results:

Plant 1.	No. 93.	Six heads	Average sound, 20;	abortive, 41
" 2.	" 253.	Four heads	" " 65	" 2
" 3.	" 93.	Five heads	" " 59	" 4
" 4.	" 333y.	Six heads	" " 7	" 64
" 5.	" 234.	Six heads	" " 31	" 36

Observations upon Salsify.

All blossoms open and close at about the same time, remaining open longer on a cloudy day than in the bright sun. Those kept under a bell jar remained open the whole day, the others closing from 9:30 to 11:30, according to the weather. A flower opens two or three times and it takes two weeks, or a little more, for the seed to mature. The color of the flowers varies from yellow, through orange and red, to a violet purple. The new plot is planted after this arrangement. The color 333 includes several shades. The yellow centers are more abundant in the orange and orange yellow flowers than in those more nearly approaching the violet. In the latter the "yellow" is very light, sometimes almost white. The flowers, especially the violet ones, faded in successive openings. Some of the flowers designated as "yellow centered" were only mottled with yellow, the amount varying from slight mottling to a pure yellow. This did not occur in the more violet flowers. There is great variation in the shape and general appearance of the plants, to which but little attention has been paid.

The black salsify is not usually self-fertile. The colors vary greatly in seed-producing capacity, but this is not a variation in the number of ovules formed, but in the number fecundated. In general, the colors more nearly like the parents produce the most seeds.

EXPERIMENTS WITH WEEDS.

After nine years, in July, of the present season, the weed experiment was brought to a close. The weeds left uncared for had a bad effect upon trial plants in the land bordering upon the untilled ground. The outer portion of the weed land offered unusual conditions for the growth of such plants as the sweet clover (*Melilotus alba* L.), which grew to great size and overshadowed many kinds of weeds that were located more centrally. One end of the ground became almost entirely covered with an aster (*Aster paniculatus* Lam. (?)), while in the opposite end a wild cherry (*Prunus serotina* L.) tree had attained a height of fifteen feet and was making a dense shade, inimical to the weed experiment in that locality. The middle of the weed plot had become overgrown with wild grapevines, which were fast choking out the other plants. The end it was not difficult to forecast, namely, the aster covering a portion of the area exclusively; a large cherry tree,

with its wide-spreading limbs close to the ground, and the tangle of grapevines climbing over it at one end of the plot, with the asters and the grapevines at the other. The longlived plants had won in the struggle for the possession of the soil.

Notes taken upon the weed belt upon June 26th record that the strongest growing weeds were the melilot, along the border, and the aster and grapevines within. A bromus (*B. ciliatus* L.) was abundant, and the following fruiting weeds were in evidence: "Yellow Rocket," "Dock," "Sorrel," "Ox-Eye," "Carrot" and "Oxalis." Two weeks later (July 10th) there were, in addition, "Fleabane," "Goldenrod," "Smartweed," "Plantain," "Bindwood," "Dandelion" and "Catch-fly." Various clovers, bluegrass and ragweed were to be found.

On account of the discontinuance of the experiment in the middle of the weed season, it is not possible to give a rank to the species the present year. It is not likely that it would differ materially from that of last season, which, with the seven preceding it, are given below:

Botanical Name.	Common Name.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.
Aster paniculatus Lam. (?)	Aster	..	..	..	..	..	13	7	1
Ambrosia artemisiæfolia L.	Ragweed	3	5	1	1	14	12	13	2
Polygonium Pennsylvanicum L.	Smartweed	6	3	2	2	4	4	6	3
Melilotus alba Lam.	Sweet Clover	..	..	..	12	10	10	4	4
Oxalis stricta L.	Oxalis	..	..	..	8	11	11	12	5
Rumex acetosella L.	Sorrel	..	7	4	3	1	1	1	6
Plantago Rugelii L.	Plantain	..	..	12	..	..	..	..	7
Abutilon Abutilon L.	Velvet Leaf	7	2	6	6	3	5	11	8
Ixophorus glauca (L.)	Foxtail Grass	..	..	..	7	..	..	..	9
Bromus ciliatus L.	Brome Grass	..	..	..	..	..	..	..	10
Daucus carota L.	Wild Carrot	12	..	..	4	5	2	2	11
Barbarea Barbarea (L.)	Yellow Rocket	..	..	..	11	..	..	..	12
Bidens frondosa L.	Beggars' Ticks	..	..	..	..	..	..	..	13
Acalypha Virginica L.	Mercury	..	..	..	..	..	..	..	14

It is seen that four of the species that were in the first list (1897) are still among the first fourteen, and it is to be observed that the ragweed holds nearly the same rank this season as it did eight years before. It has been first on the list for two years, and in 1901 it was the last to get a record. It is also to be noted that a rank-growing aster came in two years ago, and has gone rapidly to the first place.

The experience of the nine years suggests that there are many things that may interfere with the prevalence of any weed, not the least of which are qualities within the species, which, however, may be dominated by the characteristic of those weeds that are contending for supremacy. Under the conditions of the experiment the perennial species gained the upperhand, and doubtless, in the long run, the land would have become forest clad.

NOTES UPON ORNAMENTAL PLANTS.

The white-fringed phlox was grown for its third season, and some seed of this interesting cross has been saved and young plants started for next year's study.

Seeds of the morning glories that had been "hand-pinched" for nine generations were grown for two generations in the Gardens. With the aid of the greenhouse, in winter, three crops can be procured in a year. The experiment of removing the tips of the stalks results in bushy plants that produce an abundance of flowers near the ground. Last winter a plant only a foot high thus treated bore four full-sized flowers at the same time and a photograph was secured of it. The tendency to twine was very strong in the plants in the open, and unless closely watched the neglected plants will attain to great height. As all the plants under treatment were of the same stock, the flowers, often showing in hundreds, were with exactly the same markings.

Some attention was paid to the evening primroses and hybridization was attempted with several species. The species *Oenothera Lamarckiana* Ser., in which Dr. De Vries has found so many "mutants"—that is, strongly-marked forms that he calls new species—has been grown in some quantity, and one plant among them showed a marked deviation from the type.

The study of varying forms led to the setting out of a long row of the common dandelion, all gathered from the paths of the Gardens, and each of the twenty plants showing a marked difference from any of the others. In like manner a row of daisies was transplanted from a neighboring field, each of the dozen plants being of a quite distinct form from the others. One of these was so peculiar as to have all the ray flowers, although white, of the tubular shape of the yellow ones in the center of the head.

A large amount of cross-pollinating was done between the "Marsh Mallow," growing in the Gardens, and the "Rose of Sharon," in neighboring grounds. Perhaps two per cent. of the seed capsules of the hand-worked blossoms remained intact and produced seed. In this instance the union, if secured, is between a stout, herbaceous perennial that dies to the ground in autumn and a shrub of the ordinary type.

Work is in progress for increasing, by selection, the percentage of foxglove plants that produce the large, bell-shaped blooms as a monstrosity at the ends of the flowering stems.

PLATE XV.

Broom Rape (*Orobanche minor* L.) upon common "Geranium" grown in the greenhouse.

A number of crosses were probably obtained between various varieties or species of ornamental plants. This portion of the work is an aside, although one that may be as important as it is interesting.

BROOM-RAPE UPON PELARGONIUM.

The common "geranium" (pelargonium) is quite immune to attacks of the lower forms of parasite, and insects are not troublesome upon this truly popular ornamental plant, whether in the foliage and flower beds in summer or in the window and conservatory in winter. It is a matter for record, therefore, that among the few plants grown in the greenhouse last winter one should have been attacked by a broom-rape, which, when it had attained its full size, was larger than the "geranium" upon which it grew. It is the species known as *Orobanche minor* J. Esm, and has for its more general hosts the members of the pea family, and in this locality is frequently met with upon the red clover. Plate XV. shows some of the peculiarities of this parasite, including its attachment to the geranium plant.

The seed of this parasite germinates in the soil and the young roots attach themselves to those of the "geranium," after which it seeds up above ground a purplish, erect stem, bearing small, scale-like leaves of the same color, and later on a number of blooms scattered quite uniformly along the unbranched stem. The absence of green in the sun-exposed parts marks this plant as a parasite, and a close inspection of the roots shows that it gets its nourishment from another plant of the ordinary self-supporting type. In the present instance the "geranium" cuttings failed to flourish, and the cause of the sickly appearance was not far to seek so soon as the parasite pushed its stems above the ground, which resembled the tips of young asparagus shoots as they came through the soil, although the broom-rape is somewhat smaller.

There is one other broom-rape that has been in evidence in the greenhouse, namely, the *Orobanche ramosa* L., the hemp broom-rape, which grows to some extent upon the tomato plants—in fact, there were specimens of the two species in sight at the same time, and had there been the desire a hybrid possibly might have been secured between the two, with results as to the relation to host plants that are left for the imagination to supply.

FUNGI AS RELATED TO WEATHER.

The following items concerning crop plants are gathered from the "Weather and Crop Bulletins," issued weekly by the State Weather Service, during the months of April to September of the present year:

April 11th—"Wheat much winter killed."

April 25th—"Much clover winter killed;" "Raspberries somewhat winter killed;" "Strawberry blooms killed;" "Some vines winter killed."

May 2d—"Some raspberry and blackberry vines winter killed;" "Crimson clover mostly winter killed;" "Large portion of peach and early strawberry bloom killed by frost."

May 16th—"Clover wilting;" "Clover wilting."

May 23d—"All fruit trees, especially cherries, begin to show effects of recent cold winds; one-half of the blossoms blasted;" "Plums have dropped badly."

June 13th—"The severe winter weather killed all the quince and persimmon and injured the peach and papaw trees;" "Apples dropping;" "Cherries dropping;" "Some apples dropping in places."

June 20th—"Cherries rotting;" "Cherries rotting;" "Apples full and little dropping."

June 27th—"Cherries rotting badly;" "Apples dropping badly;" "White cherries rotting;" "Apples and pears dropping."

July 5th—"All peach trees in this section killed by the severe winter weather;" "Cherries rotting;" "Apples and pears dropping;" "Tomatoes badly blighted in some places;" "Apples and peaches dropping;" "Apples dropping badly;" "June drop of apples seems excessive in places;" "Early apples dropping badly."

July 11th—"Peaches dropping;" "Apples dropping;" "The Irish cobble potato especially affected by blight of tops;" "Apples dropping."

July 18th—"Apples dropping;" "Apples, peaches and plums dropping;" "Potatoes show signs of blight;" "Tomatoes excellent, only little blight."

July 25th—"Corn rolling;" "Apples dropping;" "Apples dropping fast;" "Fruit dropping;" "Corn rolling;" "Corn rolling badly;" "Corn rolling badly;" "Corn rolling;" "Corn rolling badly;" "Apples dropping badly;" "Apples and peaches dropping;" "Garden truck wilting;" "Corn rolling;" "Corn rolling, wilting in some fields;" "Corn rolling;" "Potatoes blighting, many fields dead;" "Corn is rolling;" "Corn rolling;" "Tomatoes scalding;" "Corn rolling;" "Winter apples dropping badly;" "Apples dropping badly;" "Early potatoes and tomatoes blighting;" "Fruit dropping;" "Vegetation wilting on hot days;" "Potato vines dying."

August 1st—"Apples continue dropping;" "Apples and pears dropping;" "Corn rolling;" "Potato vines dying;" "Apples dropping badly;" "Corn rolling;" "Apples dropping;" "Apples dropping;" "Apples drop heavy;" "Corn rolling badly;" "Apples dropping;" "The fatal 'brown spot' blight has begun on some unsprayed citron vines, with the citrons far from mature;" "Apples dropping."

August 8th—"Potatoes seriously affected, vines dying;" "Potatoes affected by blight;" "Apples dropping;" "Corn is rolling in places;" "Apples dropping;" "Corn rolling;" "Apples dropping;" "Corn rolling badly;" "Apples dropping;" "Early planted corn turning yellow;" "Citron vines wilting;" "Club root severe in some fields of cabbage;" "Corn drying up;" "Apples dropping considerably;" "Late cabbage seriously shortened by blight;" "Corn is scalding on light soil."

August 15th—"Apples dropping;" "The black rot is seriously shortening the tomato crop in this vicinity;" "About one-third of the apples have fallen from the trees;" "Apples dropping;" "Grapes rotting;" "Apple dropping continues on some trees;" "Apples dropping;" "Corn has scalded badly."

August 22d—"Tomato rot continues;" "Grapes rotting;" "Apples dropping;" "Apples dropping;" "Apples continue dropping;" "Tomatoes will be a light crop owing to blight;" "The tomato crop, for canning purposes, will, except in a few places, be below the average, principally owing to scald;" "Citron blight is slower than in former years;" "Apples continue dropping;" "Citrons and tomatoes blighting."

August 29th—"Tomatoes injured by black rot;" "Apples continue dropping;" "Plums much rot;" "Apples dropping;" "Tomatoes and grapes rotting badly;" "Late corn blighting in some fields."

September 5th—"Tomatoes do not ripen and are decaying badly;" "Apples continue dropping;" "Corn somewhat injured by rust;" "Early potatoes rotting."

September 12th—"Potatoes very poor in this section, owing to blight;" "Grapes rotting;" "Tomato leaves blighting rapidly;" "Corn cutting progressing, owing to so much scald the yield will not be as large as expected."

The crops mentioned in the above reports are here arranged alphabetically, thus showing the number of times a specific trouble is mentioned. The numeral in parentheses indicates the times the same disease is reported for the given date:

Apples—June 13th, dropping (2). June 20th, dropping. June 27th, dropping badly; dropping; July 5th, dropping (2); dropping badly (2); drop. July 11th, dropping (2). July 18th, dropping (2). July 25th, dropping (2); dropping fast; dropping badly (3). August 1st, dropping (6); dropping badly; drop heavy. August 8th, dropping (5). August 15th, dropping (4); about one-third have fallen. August 22d, dropping (4). August 29th, dropping (2). September 5th, dropping.

Blackberry—May 2d, vines winter killed.

Cabbage—August 8th, club root severe; blight.

Cherries—June 13th, dropping. June 20th, rotting (2). June 27th, rotting badly; rotting. July 5th, rotting.

Citron—August 1st, "brown spot" blight. August 8th, wilting. August 22d, blight; blighting.

Clover—April 25th, winter killed. May 2d, winter killed. May 16th, wilting (2).

Corn—July 25th, rolling (9); rolling badly (3); wilting. August 1st, rolling (2): rolling badly. August 8th, rolling (2); rolling badly; turning yellow; drying up: scalding. August 15th, scalded badly. August 29th, blighting. September 5th, injured by rust. September 12th, scald.

Fruit—May 23d, tree blossoms blasted. June 13th, quince and persimmon winter killed and peach and papaw trees injured. July 25th, dropping (2).

Grapes—August 15th, rotting. August 22d, rotting. August 29th, rotting badly. September 12th, rotting.

Peach—May 2d, peach bloom killed by frost. July 5th, peach trees winter killed; peaches dropping. July 11th, dropping; July 18th, dropping; July 25th, dropping.

Pears—June 27th, dropping. July 5th, dropping. August 1st, dropping.

Plums—May 23d, dropped badly. July 18th, dropping. August 29th, rot.

Potatoes—July 11th, blight. July 18th, blight. July 25th, blighting (2); dead; vines dying. August 1st, vines dying. August 8th, vines dying; blight. September 5th, rotting. September 12th, blight.

Raspberries—April 25th, winter killed. May 2d, vines winter killed.

Strawberry—April 25th, blooms killed. May 2d, bloom killed by frost.

Tomatoes—July 5th, badly blighted. July 18th, blight. July 25th, scalding; blighting. August 15th, black rot. August 22d, rot; blight; scald; blighting. August 29th, black rot; rotting badly. September 5th, decaying badly. September 12th, leaves blighting rapidly.

Truck—July 25th, wilting.

Vegetation—July 25th, wilting.

Vines—April 25th, winter killed.

Wheat—April 11th, winter killed.

Rainfall of the Growing Season for Past Sixteen Years.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	Average.
April	5.32	2.65	2.19	2.49	5.21	3.09	4.88	1.35	3.79	3.74	1.73	2.29	6.31	3.62	3.97	3.43	2.88	3.45
May	4.09	4.24	2.97	5.04	4.07	7.72	2.85	3.21	5.68	7.00	1.92	4.71	5.60	2.04	0.59	2.60	1.71	3.88
June	3.73	3.59	2.92	3.85	2.95	2.28	3.24	5.46	3.38	2.10	2.50	3.08	1.57	6.57	7.68	3.13	3.43	3.62
July	10.19	5.62	5.30	4.03	2.72	1.66	4.26	5.50	11.42	4.96	5.75	4.74	5.87	4.78	5.51	4.87	4.06	5.38
August	5.18	4.90	5.32	3.63	6.52	2.58	1.83	4.39	5.36	4.36	2.68	9.43	3.91	6.95	6.95	6.62	5.72	4.24
September	8.36	4.75	2.46	1.81	3.30	7.46	1.07	4.37	1.65	2.00	5.88	2.86	3.38	5.65	3.34	4.79	5.23	4.01
Totals	36.87	25.75	21.16	20.85	24.67	24.79	18.83	21.72	30.31	25.16	22.14	20.36	32.16	26.57	28.04	25.43	23.03	24.58
Average	6.14	4.30	3.53	3.47	4.11	4.13	3.14	3.62	5.05	4.19	3.69	3.39	5.36	4.43	4.67	4.27	3.84	4.09
Rank in wetness	1	6	14	15	10	9	17	13	3	8	12	16	2	5	4	7	11	...
Rank in dryness	17	12	4	3	8	9	1	5	15	10	6	2	16	13	14	11	7	...

Temperature of the Growing Season for Past Sixteen Years.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	Average.
April	51.2	50.4	52.0	49.3	49.2	50.3	49.1	52.4	50.4	47.8	49.9	50.8	48.3	50.2	50.9	46.7	49.9	49.3
May	62.3	60.7	59.5	60.1	59.4	61.4	60.9	65.3	60.6	58.5	61.1	60.9	58.6	60.3	62.7	62.8	61.4	60.9
June	69.9	70.7	69.7	72.4	69.7	70.6	71.7	68.1	66.1	70.1	72.3	70.4	70.0	67.5	64.0	68.6	68.3	69.3
July	73.4	72.5	70.1	74.3	73.9	75.7	70.9	75.0	74.1	75.3	74.7	75.9	77.3	73.0	73.3	72.3	74.4	73.9
August	69.6	71.5	72.8	73.4	72.8	70.9	74.2	73.6	71.0	74.8	72.3	76.3	73.8	70.1	68.4	70.8	71.1	72.1
September	64.8	64.4	68.7	64.2	62.7	68.3	69.7	65.1	65.5	68.6	64.4	69.9	66.8	64.6	65.0	64.8	65.4	65.9
Average	65.2	65.0	65.4	65.6	64.6	66.2	66.1	66.6	64.6	65.9	65.8	67.4	65.8	64.3	64.0	64.3	65.1	65.2
Rank in warmth	11	12	9	8	13	3	4	2	14	5	6	1	7	15	17	16	10	...
Rank in coldness	7	6	9	10	5	15	14	16	4	13	12	17	11	3	1	2	8	...

Sunshine of the Growing Season for the Past Sixteen Years in Percentage of Clear-Partly-Cloudy Days.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	Average.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
April	53	76	80	53	60	70	60	76	83	62	87	77	50	70	66	70	77	70.1
May	65	66	64	71	69	65	78	71	78	52	77	75	58	84	84	84	74	70.9
June	66	80	76	76	70	83	73	73	80	87	84	80	87	83	53	77	77	76.8
July	58	76	69	84	87	84	78	74	68	74	77	87	71	71	84	74	81	76.4
August	74	77	61	78	81	80	90	87	84	77	71	84	71	90	65	81	74	77.9
September	53	66	83	87	73	66	90	70	87	83	80	80	80	60	83	80	76	76.4
Average	61.5	73.5	72.2	78.2	73.3	74.7	78.2	75.2	80.0	72.7	79.3	78.9	69.5	76.3	72.7	77.7	76.5	74.7
Rank in brightness	17	16	15	4	12	10	5	9	1	13	2	3	16	8	14	6	7	...
Rank in darkness	1	7	3	14	6	8	13	9	17	5	16	15	2	10	4	12	11	...

The rainfall has been somewhat below the average during the growing season, due in large part to the very dry weather that prevailed in April, and particularly through the month of May, when only 1.71 inches fell, as against the normal of nearly four inches. August and September were the only months which were above the average, the former exceeding the normal by an inch and a half. As July was near the normal, it is seen that the season was divided into a dry first half and a second half that was somewhat above the average in precipitation. These conditions were unfavorable for all early crops, but the later rains and the absence of frosts made amends for this in the summer and autumn months.

Among the seventeen years recorded in the table the growing season of 1905 ranks eleventh for wetness, and therefore seventh for dryness, and, taken as a whole, is very near the average for the whole group of years named.

In temperature the growing season of 1905 was, as a whole, quite close to the normal, it being only one-tenth of one degree below the average for the last seventeen years. It was above the average for April and May—that is, during the dry period; exactly normal for June and above for July, normal for August and a little below the average for September. In warmth it ranks tenth among the seventeen years that the writer has been in charge of the department.

The tables for sunshine are not so easily constructed as for rainfall and temperature, but the estimates show the growing season was somewhat brighter than the average. Its rank is seventh among the past seventeen seasons.

If dryness, warmth and clearness are considered, it is found that the rank for each for the past season is seventh, tenth and seventh, respectively. It is to be observed that the temperature of the seventh and tenth in rank differ only in one-half of one degree, so that there is essentially a close relationship between the dryness, warmth and clearness of any season. Thus the season of greatest rainfall in the whole seventeen, namely, 1889, is the darkest, but there were some others that were somewhat colder. Thus the season of 1900 was, in dryness, warmth and sunshine, second, first and third, respectively.

When the facts concerning the fungous diseases, as reported by the weather crop correspondents, are compared with those of previous seasons and with the weather for the same period, it seems evident that there is a close relationship between the two sets of phenomena.

Fungi upon the Experiment Grounds.

Upon the Gardens the fungous diseases most in evidence were the mildew (*Phylophthora Phaseoli*) upon the lima beans. It seemed to attack both the pole and bush sorts nearly equally, but of the latter the small, thin-podded sorts, like "Jackson Wonder," were the least affected. The pod-spot (*Coletotrichum*) was in evidence, both in the spring and autumn crop, but particularly so with the latter crop. For the first time, to be at all serious, the bean rust (*Uromyces appendiculatus*) developed upon the crop in the Gardens. Upon this account, and as there were many varieties exposed, a study was made as to the susceptibility of the different sorts. Many were entirely free from the rust; several had it only upon the stems or foliage, while others, always of the green-podded group, showed it badly upon the pods, and such varieties as the "Tennessee" were nearly ruined. The sweet corn showed some smut, which was much more abundant upon the "Malakhov" than elsewhere. The same report has come in from several growers throughout the State. The tomatoes were quite free from all troubles, excepting a variegation of the foliage, resembling a disease in tobacco—a closely related plant to the tomato—which has taken the name of "Mosiac." This yellowing, in spots, of the leaves seemed to be inherent in the young plant, and it was not observed to spread to other plants in the field. The eggplants were quite free from leaf blight, excepting the "Scarlet Chinese," the foliage of which became very spotted toward the close of the season.

Asparagus Rust.—The rust upon the asparagus has not been as abundant this season as in some former years. This may be due, as some large growers claim, to the general use of the more resistant varieties, as the "Palmetto" and "Argenteuil," or French sorts.

REMOVING AND PRESERVING SEEDS.

In the saving of squash seeds, that are easily moved by the wind and thus liable to mixing when several crosses are spread out to dry, it has been found convenient to place the washed seeds—the poor ones having been floated off—in roomy bags of mosquito netting, fastened (tied) with the same wire-wood label that was removed from the hand-worked squash, with all its items of record. Such loose bags permit of the seeds being spread out upon the drying frame of lath, made

with wide spaces between the strips, where they can be readily turned until fully dry. They are readily stored in the same bags in the tin boxes arranged in pigeon-hole cases.

The finer mesh of mosquito netting has been used for the drying of eggplant seed, which otherwise is easily blown away or might become mixed with other crosses.

In the harvest of small quantities of beans the seeds are beaten out with a short stick upon a sail cloth, from which the seeds are gathered and placed in mosquito netting bags and hung by the wire label to horizontal wires. Lima beans in the small quantities are, after drying in the mosquito netting bags of large mesh, placed in gunny sacks and beaten as the other beans, without the danger of loss or mixing by flying as when uncovered.

The method of securing and preserving the tomato seed is as follows: The mature fruit, with the broken paper bag still perhaps half surrounding it and making the "crossed fruit" easily found, has its thoroughly washed seeds spread upon a sheet of paper, eight and one-half by eleven inches in dimensions, to which the contents of the label are transcribed and any other desired notes. Where the case seems to demand it the fruit, when cut in halves, is outlined upon the sheet with a sketch in detail of the interior structure. The natural mucilage of the seeds causes them to adhere securely to the sheet, which can be pinned with those of its own "family" and kept in tin boxes out of reach of mice. At planting time each sheet to be used is turned bottom side up and given a sharp snap to insure the removal of any seed that might possibly have become detached and got out of place. The removal of the seeds from the sheet for planting is a partial record of the fact through the "scars" that are left upon the paper. However, the pencil is needed to add the date, number of seeds removed, etc.

NOTES UPON THE KEEPING OF RECORDS.

The question frequently arises as to the possibility of keeping the progress of breeding experiments closely in hand, so that the one in charge may at a glance know the history of the plants he is dealing with then and there. It is doubtless true that the perfect system of making records is still to be formulated, and as yet, in a measure, each breeder is working upon somewhat independent lines that, while necessarily agreeing in essentials, vary greatly in details.

Blank books, five and one-half by eight and one-half inches and one inch thick, are now more used than the smaller sizes in vogue during the earlier years. Certain of these books are with an alphabet leaf index, giving a half-dozen or so of pages to each letter. Other books of the same size are without the index. The following is a sample of the title of one of the books for the present season: "Tomato Crosses—Gardens, 1905." In this a third of a double page is given to each cross. The left-hand page of the double page records the historical portion of the cross and the other facts, that are given in contracted form, while upon the right-hand page more general observations are written out. To illustrate:

$$\frac{\frac{123}{85}}{\text{II.}}, \textbf{3/25.5.8/31 St. Fl. R. S. M. Rd.}$$

This means that the variety "Stone" (123) was crossed upon "Michigan" (85), and the Roman numeral II. below the fraction bearing the variety numbers shows that this is the second generation of that cross. The row of five plants was set in the Gardens upon March 25th (3/25). The five (5) plants all did well enough to be considered in the test, and upon August 31st (8/31) the following general observations were made: The plants were all of the standard (St.) type, with foliage of the fine-leaved (Fl.) sort. The fruits were round (R.), smooth (S.), medium (M.) in size and of a red (Rd.) color.

These symbols occupy one line and below them is space for any remarks to qualify the above general record. Upon the right half of the page observations like the following were recorded: "An even and thrifty lot of plants of medium size." "An average of five ripe fruits per plant in sight." "A very even-rowed set of fruits, which were a little inclined to crack upon the 'shoulder.'" "Seed was saved." Later, notes of inspection are made under the proper dates.

In this book the crosses are arranged so that all the members of a "family" are brought together, as they were in the field, which facilitates the study of crosses having the same "blood."

The five plants in the row of tomatoes are recorded as *a*, *b*, *c*, *d* and *e*, beginning at the upper or eastern end, and when the flowers of a selected plant are "hand-worked" (pollinated) within that plant—phyto-fertilized, as it might be termed—the record upon the wire-wood label indicates the fact by the letter which stands for the plant in the form of a fraction. Thus $\frac{d}{d}$ means that the seed secured was

from plant *d* and fertilized with pollen from another flower of the same plant, while $\frac{a}{e}$ signifies that the pollen for a flower upon the lower or stake plant was obtained from the head plant in the row.

When each variety receives a number as it enters the breeding grounds, it is not difficult to keep a record of its combinations by the fractional method. For example, the "Currant" tomato, a separate species, the *Solanum pimpinellifolium* Dunal, when its seed was sown in the greenhouse, took the lowest unoccupied number for tomatoes, namely, 177, and this it must keep until the end. The books show this number in combination with several others, and the following are selected at random: $\frac{177}{144}$ This is the first generation—that is, the first set of plants from the cross—and the record shows that this combination with the little "Currant" tomato, with its slender vines and round, red fruits, when pollinated upon the "Golden Queen" (144), a large yellow-fruited variety, gives, to quote from the record book: "Enormous vines, with long clusters of cherry-red fruits." The "Currant" has great prepotency and dominates over the cultural varieties of the more common garden species. Again, $\frac{177}{\frac{128}{\text{II.}}}$ is the second generation (indicated by Roman numeral below) of "Currant" upon "Sutton's Best of All," a fine, large, red-fruited, standard sort. This continues to give very large, long vines, abounding in long clusters of red fruits, averaging below an inch in diameter. In this way a "red plum" has been brought into existence, and it is to be predicted that the third and later generations will continue the same general character of long vines and clusters and small, round fruits, useful for pickling. Further, the book records a cross between two crosses, as shown by the following double fraction $\frac{\frac{177}{122}}{\frac{75}{103}}$. Here the "Stone" (122), "Magnus" (75) and "Ponderosa" (103), are all combined with the "Currant" (177). The record shows that these "vines" were the largest upon the breeding grounds, with plants very uniform, bearing long, unbranched clusters of red fruits averaging one inch in diameter. It is to be remembered that the "Ponderosa" is one of the very large-fruited sorts, while "Stone" and "Magnus" are both of good, medium

size, and yet the "quarter blood" of the small "Currant" was able to pull against the three and control the form of the fruit cluster and the type of the fruit. It illustrates that it is easier to drag down than to build up. It is also to be noted, in passing, that the red color of the "Currant" (and "Stone") prevails against the pink of both the "Magnus" and "Ponderosa."

Next season plants from this double cross, hand-worked within the combination, would be recorded upon the stake by the same fraction,

with the addition of the Roman two (II.) below, thus: $\dfrac{\frac{177}{122}}{\frac{75}{103}}$ II.

Other vegetable fruits are treated in a similar manner as to record numbers. Thus each kind of truck crop under breeding trials has its own set of numbers, provided there is no hope of breeding them together. Thus sweet corn had numbers up to 105 before the subject of popcorn was added to the list, and as it may be desirable to breed these two groups together, the popcorns, of which thirty-six numbers were added this year, must be recorded from 106 to 142, to avoid any confusion. In the same way all kinds of beans, whether bush, pole, string or lima, come into the same series, although there is much less hope of a combination between the last two than elsewhere. All the squashes are numbered in the same series, but the breeding affinities are very distant between the two leading species represented.

The Marking of Stakes.

As experience is gathered from year to year, the importance of large, deeply-set stakes for all rows and special plants in the grounds becomes more and more emphasized.

When a plant is first set or a row planted with seeds a six-inch stake seems large enough, but plants increase and stakes decrease, or get trodden down, broken off or inexplicably mixed up, when there are workmen removing weeds and visitors of all kinds passing through the grounds. The only safe way is to set a stout stake at the head of each row before the plants are added or the seeds are dropped. These stakes need to be at least two feet long and driven in a little slanting toward the row, fully fourteen inches. They should be plainly marked before being placed where they are to remain during the life of the

plants they record. The lettering—if names are employed—should be large and clear and lasting, that no doubt may arise from obscurity. Of course, there is a plotting of each block of plants recorded in the field-book of the crop, so that when labels are destroyed from any cause they can be replaced with certainty. The stakes, aside from giving the history of a cross by bearing the fraction above noted, are a means of recording certain events as to each row. For example, herbarium specimens are taken from each cross, and a mark, as "S," with a blue pencil, makes a convenient record upon the spot (stake) of the fact that the specimen has been secured. In the same way another mark indicates that seed from some specially early plant has been saved. Should it be desirable to mark the plant this may be done with a wooden wire-label or a larger one of cardboard—a shipping tag—when the plant is a leafy one and small labels are quickly overgrown. With squashes, for example, tall, white stakes, placed close by the side of plants to be designated, have proved a more acceptable guide in pollinating work than any kind of showy label that was devised. In fact, among beans and tomatoes, quickly-seen stakes are a great advantage in facilitating the work of getting quickly to the plants that are to receive special attention.

The following are some of the marks upon stakes and labels that have been in use upon the Gardens:

1. The Variety. The name in full with source—"Paragon" Liv.

2. The First Cross. A Fraction, the male parent as the numerator, $\frac{102}{113}$, for example ("Bismarck" upon "Detroit Wax" Bean).

3. The Compound Cross. A Compound Fraction $\dfrac{\frac{210}{169}}{\frac{75}{103}}$. This shows that the simple cross $\frac{210}{169}$, for example, "Station Yellow" tomato upon "Dwarf Stone" was crossed upon a cross of "Magnus" (75) upon "Ponderosa" (103).

4. Generation. Roman numeral below the fraction $\frac{99}{19}$, for example, III.
"Black Mexican" sweet corn upon "Country Gentleman" during the third year for the cross.

PLATE XVI.

Stake Labels, Post Packets and Methods for Drying and Preserving Seeds.

5. Row Stakes. Capital Letter H. $\dfrac{\frac{5}{6}}{\frac{6}{5}}$, for example, shows the row filled with plants that are a compound cross of "Crookneck" (5) squash and "Scallop" (6). The large letter facilitates work in the field and in making records.
6. Plant in row. Italic Letter. For example, $\frac{6}{d}$; the second plant (b) is used to pollinate the fourth plant (d). This is used upon tie labels, and the plants are lettered from the upper or east end of the row, as for example, with tomatoes.
7. Quality. A Scale of Points upon a "shipping tag." Plant 50 (Earliness 15, Prolificness 35, Form 10). Product 50 (Quality 30, Appearance 20). This is used, for example, upon sweet corn, as a large tie label (shipping tag) during the growing season, and ears are saved for seed from the best plants thus recorded.
8. Signal Stakes. These tall, white stakes are used for marking conspicuously any row or plant for special treatment, and are much taller than the plants to be marked.

Somewhat in repetition of the previous remarks the following explanation of Plate XVI. is given: The largest variety stakes that are used upon the plots are about two feet long and three inches broad. In some instances the name of the variety only is written, in black paint, with fine brush. After a variety has been upon the books for some time its number may only be placed upon the stake, and when it is in a cross the number representing the male is written over that for the mother plant. Thus in the picture the $\frac{151}{39}$ stands for a row that bears cross-plants. When the cross is grown for a second crop a Roman numeral is placed below the fraction representing the cross. Thus in the third stake the plants thus marked are the third generation of 34 (whether beans, tomatoes, squashes, sweet corn or egg-plants, as the crop decides) upon number 12. When one cross is bred upon another cross the fact is recorded in the books and upon the stakes by placing one fraction (the male) over the other with two horizontal lines between. The number of horizontal lines indicates the number of new combinations.

If the double cross represented upon stake *d* was bred with a variety, or another cross, the fact could be quickly recorded by drawing three horizontal lines between the two sets of figures, and the portion above the three lines would be the male.

The same form of fractional record is employed in ticketing all

seed packets. Fine mosquito netting has been found of great service in drying seeds like those of eggplants, squashes, etc., that are easily blown by the winds. At *f* is shown a packet of beans freshly shelled and drying, the wire-wood label indicating securely the cross, its generation and the year. The date of saving the seed is usually added to the label. For more permanent use the small seeds are placed in cork-stopper vials (*g* and *h*), with paster labels placed close to the cork, that as much of the seed as possible may be in sight. The sweet corn for special study is kept upon the ear by dipping the whole ear in melted paraffine to keep the grain from shelling. An ear thus preserved since 1903 is shown at *i*. Tomato seeds, fortunately, are surrounded with sufficient adhesive pulp so that they can be dried upon sheets of paper, to which they adhere, and may be marked as shown at *j*, which represents a sheet ready to be placed in a gum-flap packet shown below it (*l*) and marked for popcorn. The tomato seeds sheet shows that it is from the third generation of "Magnus-Ponderosa" (Magnerosa), and came from pollinating plant *a* with plant *d*, upon July 13th, and the seed was harvested August 26th. A mailing packet is shown near *m* and marked for "Station Bush" lima beans.

Other aids in the field work are large tickets (*n*), borne by the plants upon which from time to time notes are made to aid in selecting for earliness, productiveness, form of plant, these making up half of the hundred points in the "scale of points" for superior plants. An ordinary bag, with its wire-wood label marked to indicate a pollination, is shown at *o*. A row of beans sometimes is quite conspicuous because of these bags during the breeding season. After fertilization is secured the bag is torn open, but left upon the plant as a conspicuous mark.

INK PRINTS OF VEGETABLE FRUITS.

The serious difficulty in the way of making satisfactory records of the interior structure of soft fruits, like those of the tomato, has in part been overcome by resorting to ink prints. These prints are secured by cutting the fruit when full size, but not fully mature, and inking the cut surface after it has dried a little, and pressing the cut surface upon an ink pad of large size and applying the inked surface to white paper. It is quite essential to have a long knife with a broad blade and keen edge, that the surface may be very smooth and as nearly

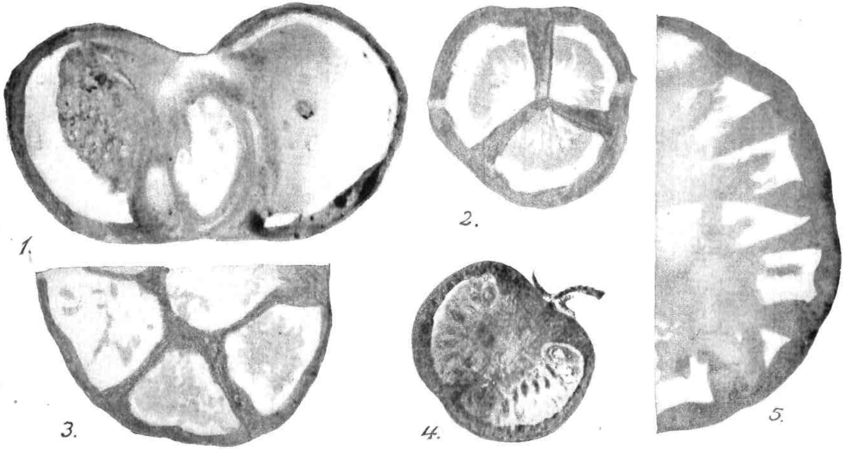


PLATE XVII.

Ink Prints of Tomatoes—*1*, "Crimson Cushion-Giant" upon "Giant"; *2*, No. 3151 U. S. D. A. (Italian), upon "Yellow Pear"; *3*, "Golden Queen" upon "Aristocrat-Golden Queen"; *4*, "Ignotum" upon "Red Plum"; *5*, same as No. *1* cut flatwise. All are natural size.

in one plane as possible. Black ink has proved more satisfactory than red or blue. It has been an advantage to stamp the section a few times upon refuse paper before the permanent print is made upon the sheets selected for preservation. Two sections have been taken of each fruit selected as a representative of the commercial sort or cross therefrom. Practically a full set of such prints for the tomatoes was secured the present season. It was found most convenient to first make a print of the axial section—that is, by cutting the fruit from stem to opposite end and then cut these two halves at right angles to the first printing surface and the axis of growth. A better print can be made by taking a separate fruit for each view, but experience shows that it is well to use the same fruit for both the longitudinal and the transverse print.

In the first-named section the width and depth of the fruit are shown; the wall, whether thick or thin, is clearly given, and something of the interior structure, while the transverse print gives more of detail of the interior of the fruit, as, for example, the number and size of the seed cavities (lodicels), the thickness of the partitions, and also of the outer wall, in addition to the size of the slice that may be taken across the fruit. Plate XVII. shows something of the nature of the ink-prints, samples of which were cut from the record sheets and reproduced in the engraving, natural size.

A similar set of prints was secured of the beans, in this case showing the pod cut lengthwise when fully grown, but immature, and a view of a section across the pod made through the middle of the seed and another between two adjoining seeds. Such a print records the exact size of the pod in length and width, while its thickness is given in the two transverse views. The number, size and location of the seeds are shown and made as to the thickness or fleshiness of the pod.

Squashes and eggplants can be similarly shown in section, while cucumbers lend themselves particularly to the making of such ink-prints. Sweet corn in transverse section of the ear, while young, is quite satisfactory as to many of the details. The list of subjects can be extended indefinitely.

REPORT OF THE ENTOMOLOGIST.

REPORT OF THE ENTOMOLOGIST.

BY JOHN B. SMITH, SC.D.

GENERAL REVIEW.

The winter of 1904–05 was not a severe one, albeit the cold was continuous and freezing weather extended well into the spring months. There were no spells of very low temperature, however, and altogether it was a good winter for hibernating insects. Fruit trees started at New Brunswick about a week earlier than in 1904, but were held back by subsequent cold until, by the beginning of June, a normal season was at hand. Then came a period of dry weather of unusual length, though not equally marked in all portions of the State. With this came also a few days of excessively hot weather, which had a serious effect upon some of the city shade trees, especially maples. After midsummer, when the drought was broken, there was rain in abundance everywhere. In a general way it may be said that the season was favorable to insect development, and if there were no remarkable outbreaks, there was at least a very uniform record of injury on many kinds of plants and trees.

THE SAN JOSE SCALE.

This insect continues to be the most important of those affecting our fruit crops, and there are now few localities where it does not occur. Nevertheless, there are such localities, and in most of them the fruit-growers keep a close watch for signs of infestation. In many cases the owners of small, infested orchards have given up the fight, and some old orchards, especially of peach, have been abandoned. The peach trees usually die promptly enough, and disappear as a source of danger; the apples linger for several years, dying down slowly and gradually unless cut out. At the same time, even in localities where the scale occurs, there are orchards in which good, clean fruit is secured,

and which pay satisfactory returns. The early brood of larvæ in 1905 was unusually heavy, and more spotted fruit than usual was seen before the beginning of July. But the later conditions were less favorable for their development, and the second brood was not nearly so large as was threatened. Nothing new has developed in the life history of the species and no new natural check has been discovered.

It is not infrequently asserted that there is some natural enemy that is active on unsprayed trees, and it is undoubtedly true that some orchards that have never had treatment of any kind have remained remarkably clean. But this does not seem to be due to the presence of any parasite or specific disease; the insects simply do not multiply. Whether that is due to any surface condition of the trees or to some physiological peculiarity seems to be incapable of determination at present. It is certain, also, that some orchards that were once badly injured and left to themselves have in a way recovered and adapted themselves to the presence of the insect. But, on the other hand, the further fact remains that entire orchards of apple, pear, peach and plum have been completely wiped out by the scale, and that it would be taking large risks to trust to natural exemption when an infestation is first recognized.

Fig. 1.
Half grown scale, showing condition in which winter is passed; much enlarged. From Bull. Va. Sta.

But, while nothing new in the life history has been discovered, it is believed that a somewhat different period of applying insecticides is indicated by experience. Heretofore the tendency has been to postpone the applications to the last possible moment, and we have advised spraying just before the trees made a start. This seems to be hitting at the insect while it is yet in its dormant and most completely protected condition and before spring development has begun. The reasons for advising this period has to do with the effect of the insecticides on the trees, and with the belief that late applications would remain long enough to be, in a way, protective as against the first brood.

Whale-oil soapsuds were found to be destructive to fruit buds if applied in early winter at a strength sufficient to kill the insects. Petroleum was found to be more likely to cause injury when allowed to soak for months into a dormant bark than when applied on an active

surface with sap-filled cells; and as to the oil, it was certainly true that a greasy coating remained long after the trees had started.

But experience seems to indicate that trees are almost equally resistant just before they become dormant, except against fish-oil soap and that the scales at that time, being still in the full tide of activity, are much more susceptible.

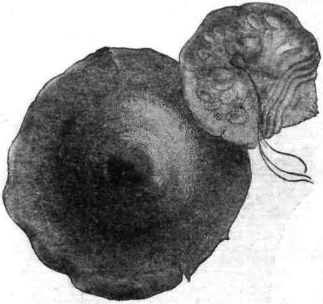


Fig. 2.

An adult female scale from below; the real insect is below and to the right, separated from its covering. Much enlarged. From Bull. Va. Sta.

We know positively, now, that the soluble petroleum or emulsions will cause no injury to fruit buds or tree when applied in late October and early November, and such work as has been done with the lime and sulphur combinations indicates the same thing for them. The K.-L. has been used at almost all strengths during summer and winter, and should be no more harmful than undiluted kerosene, which has been safely and effectively used.

My suggestion is, therefore, that the best time for spraying against the scale is when the fruit is all off; when the foliage is mature—just ready to drop—and while the scale is yet active. This period will vary with locality and with the kind of tree. By the middle of October, in the northern part of the State, peach trees may be treated, and by the first of November apple trees will be ready. In the southern section the scales have been found yet active early in December, but such specimens stand no chance of surviving.

No scale that begins to breed in fall lives through the winter, no matter how few young she has born, and no fertilized female ready to bear, survives. No larvæ born after the sap has ceased to circulate reach a stage that will carry them safely until next season. Only those survive that reach the half-grown black stage, when the scale is thickest and most closely applied to the trunk. These are the forms

that swarm on the trees as larvæ in early October, and these are the insects to be aimed at. The fact that no reproduction takes place until after June 10th, and that when it does begin almost every female is at work within a week, indicates a remarkable uniformity in the state of the development of the hibernating forms.

As to the insecticide, that may be anything that the fruit-grower is familiar with and in which he has confidence. Personally, I prefer the soluble oils, elsewhere described in this report, and they are probably almost equally effective. K.-L., properly made and thoroughly applied, would come next in order, and then the lime and sulphur combinations. If the regular boiled mixture is to be used, the amount of salt may be reduced to one-fourth of the normal quantity, assuming that the formula recommended by me is used. The self-boiled mixture, without salt, may be used if carefully made, but the caustic soda formula had better be used experimentally only. It is believed to be the caustic soda that causes injury to fruit buds, and for that reason no wash containing any large percentage of it can be considered safe. On peach orchards the lime-sulphur mixtures have a claim to first place because of their influence on leaf curl and other troubles, and because, somehow, they seem to improve the condition of the trees.

Fig. 3.
Scale on a branch, showing adult females and recent sets. Much enlarged. From Bull. Va. Sta.

Whatever is used should be applied as thoroughly as may be, and the spray should be driven into the trees with as much force as possible. One application, October 15th, and a second, November 1st,

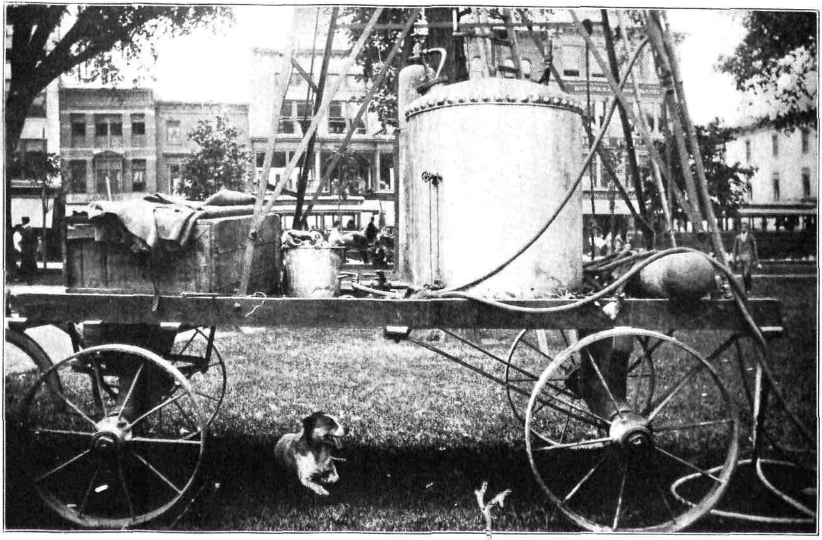


Fig. 4.

The spraying outfit in use by the Newark Shade Tree Commission. From an original photograph.

Fig. 5.

The Niagara Sprayer and crew in action, at Newark. Two leads of hose each with 4 nozzles. From an original photograph.

may be made if the soluble oils are used, and the dilution for the first spraying may be 1 to 25. If only one spraying is made it should be 1 to 20. If the K.-L. is used and two applications are made, 20 per cent. kerosene will be sufficient for each. If the lime and sulphur mixtures are to be used one application only, at full winter strength, is advised; but in the case of badly-infested trees a second application may be made in spring.

It is believed that the practice here recommended will give much better results than any that has heretofore obtained.

THE PEACH SOFT SCALE.

In 1904 specimens of small, brown, soft scale were sent in from Bridgeton, with the report that it was plentiful and injurious in some peach orchards. In the summer of 1905 further communications were received, and after some correspondence I sent Mr. Dickerson to investigate, on the occasion of a nursery inspection trip, and later visited the infested territory myself. The insect turns out to be a European species, which up to the present period had not been known to exist in New Jersey, and even now seems to be confined to a small area lying southward from Bridgeton. As there is a possibility of its spread it is deemed well to give, on another page, a brief account of the life cycle of the species, taken chiefly from a paper on "Some Scale Insects of the Orchard," published by Dr. L. O. Howard, in the Year-Book of the United States Department of Agriculture for 1904.

SHADE TREE NOTES.

There has been much complaint of injury to shade trees of many kinds, and the general tendency has been to charge insects as the cause of the trouble, but not justly in all cases. Tulip trees have in many places lost a large part of their foliage, which turned yellow and dropped. Some of the leaves had one or more large brown or blackish blotches, and when these were sent to me I recognized the work of a leaf-miner, the larva of a small fly; but this did not account for the dropping of that vast majority that showed none of these spots. Conifers on lawns and in parks were also attacked by some disease that caused them to turn brown and die, and on these a little *lepidopterous* borer in the pine needles, or a plant-louse at their base,

were unjustly accused of the injury. Elms suffered less than some other trees, except that the injury directly due to the elm-leaf beetle was much intensified by the drought. Maples of all kinds suffered from one cause or another, and the hard maples were, on the whole, much more injured than the soft varieties. The latter were the especial hosts of the cottony scale, but that insect met with the expected natural check in the form of the little geminate *Hyperaspis*, as is detailed at some length in another portion of the report. The hard maples became infested after midsummer by the false scale (*Pseudococcus aceris*), but that was not accountable for the mortality among them. The trouble was described thus: "This begins by the top and outer extremities, or perhaps a limb dying the first year, and then the rest of the tree goes, until in two or three years the entire tree is dead." Complaints of this character came from many places, but more, on the whole, from the hilly towns on and near the base of the Watchung mountains. To attribute a probable cause to this effect would be mere guesswork, and as the insects were certainly not in fault, its investigation was not matter for this department.

Shade trees, as a whole, have had more care and attention throughout the State than ever before, and there has been a steady demand for copies of Bulletin No. 181, dealing especially with the insects injurious to them.

During the past season the Shade Tree Commission of the city of Newark has made systematic efforts to improve the condition of the trees in the streets and city parks which were placed under its jurisdiction. A 150-gallon Niagara gas sprayer was purchased, together with an outfit of poles, nozzles and hose that would make it possible to reach the tops of the highest trees. The sprayer worked well and proved especially satisfactory, because there was nothing in the way of machinery to get out of order, and because exactly the amount of pressure needed was always available. Kill-O-Scale as a contact insecticide and arsenate of lead as a stomach poison were used, and the insects especially dealt with were the cottony maple scale, the elm-leaf beetle and the vaporer moth. Incidentally, of course, quite a number of other species were reached, and, altogether the condition of the trees was materially improved.

During the winter the trees had been shaped up, borer-infested limbs were cut off and dead wood generally was removed, all of which simplified the task of spraying materially.

Fig. 6.
Sugar Maples on Midland Avenue, East Orange, as shaped up by the Shade Tree Commission. From an original photograph.

Fig. 7.

Spraying outfit of the East Orange Shade Tree Commission; the Secretary, Mr. Solotaroff, at the front of the wagon. From an original photograph.

An interesting experiment was made, when, after the first brood of the *vaporer moth* had hatched and egg masses began to appear on the trees, a reward of ten cents per quart was offered for egg-masses, to be brought to a specified point at a specified time. Mr. Carl Bannwart, who was in general charge, reports that altogether a little less than $20 was expended. By actual count, one lot of two quarts contained 387 egg-masses, and a three-quart lot sent to me contained 425 egg masses, the balance being made up of cocoons, pupæ and the like. This makes an average of 166 egg-masses per quart. At my request, Mr. Dickerson counted the eggs in four masses of average size, obtaining as the result 369, 412, 327, 470, or an average rate of 349 eggs per mass. At that rate each average quart would contain about 65,404 eggs, and the 200 quarts for which $20 was paid, purchased 13,080,800 eggs. This is not exactly a bad investment, especially as experiments showed that most of the eggs were viable.

In East Orange the spraying outfit is modeled after that employed by Mr. E. B. Southwick, the Entomologist to the New York Park System, and a three horse-power Daimler gasoline engine furnishes the power. The cottony maple scale was the species more particularly aimed at there, and, instead of using an insecticide, a solid small jet was used to dislodge the insects when they became prominent. Two nozzles employed in this way cleaned a good-sized tree in twenty minutes. This method has the merit of simplicity and safety to foliage, and seems to have been very successful. In towns and cities with good water pressure, an ordinary garden hose could be used to good purpose for the same end.

In other cities and towns throughout the State various measures were adopted. Sometimes the governing bodies of the municipality provided the necessary funds, but quite frequently local improvement associations attended to the work from funds paid in by members or from those whose trees were treated.

OYSTER-SHELL BARK-LOUSE.

The *oyster-shell bark-louse* as a shade-tree pest has not been heretofore especially troublesome; indeed, except on some butternut and walnut in the northern counties, it has been a negligible quantity. When it occasionally became rather plentiful on some orchard trees, a single treatment in June was advised and was generally all that was

needed. On lilacs, when it became troublesome, it was suggested that the worst infested shoots be cut out, and more than that has not been necessary.

Complaint has been made at Hammonton for two years last past that the city shade trees were badly infested by this insect, and that

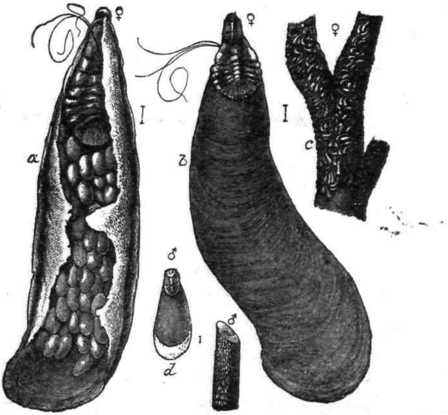


Fig. 8.

The Oyster-shell Bark-louse, *Mytilaspis pomorum* Bouché: *a*, female with the egg mass beneath the scale; *b* same from above, showing the normal appearance of the species; *c*, a twig infested by females; *d*, the male scale, natural size and enlarged. From Div. Ent., U. S Dept. Agric.

maples in particular were actually dying under the attack. Whe these complaints were renewed in the spring of 1905 I advised th application of whale-oil soap, one pound in five gallons of water, whe the larvæ were active, and that active period began, as we observed fro specimens sent in, as early as May 15th, young scales being alread set May 26th. In mid-July specimens sent in contained what seeme a mixture of partly grown and hibernating scales, but a second sampl received a week later, proved that at Hammonton this insect is tw brooded, and that larvæ of the second brood begin to move during th

last days of July. I was also advised that, at the rate of one pound in five gallons of water, whale-oil soap was not satisfactorily effective, and at one pound in four gallons of water obvious injury was caused to the foliage of maple. No other kind of tree suffered quite as much; but it must be added that not all the injury to maple was due to insect attack.

ELM-LEAF BEETLE.

The *elm-leaf beetle* has been more abundant during the past summer than for three years last past, and, assisted by the generally droughty conditions, the trees have shown marked injury. At New Brunswick the hibernating brood was not large and the early feeding was inconspicuous. Egg masses did not seem especially abundant, and it was decided that it would be unnecessary to spray; but the larvæ developed absolutely without check, the scraped leaves withered under the effect of the intense heat and dryness, and trees were almost defoliated early in August. At that time the brood was mature and beetles in great numbers had emerged. There was no killing off by fungous disease, and there is a heavier brood in hibernation than there has been at any time during the five years last past. It is, of course, impossible to say what the coming winter and spring of 1905–06 may bring forth, but unless some very marked disaster overtakes the insects there will be a heavier brood next summer (1906) than there has been for many years past. In other localities the injury has been less marked than at New Brunswick, but everywhere it has been notable.

THE GYPSY AND BROWN-TAIL MOTHS.

Late in July reports of the alarming spread of the *gypsy* and *brown-tail moths* in Massachusetts began to be received, and assertions were made that the insects had been found in New York and even New Jersey. It was learned, also, that the legislature of Massachusetts had again appropriated a large sum of money to assist municipalities in dealing with it, and that Mr. A. H. Kirkland, formerly connected with the work done by the Committee of the State Board of Agriculture, was now in charge of this attempt. It was deemed wise, in view of this situation, to make a personal investigation, and this was done—first, between August 8th and 10th, and again later, between Sep-

tember 19th and 23d, in company with Dr. E. P. Felt, the State Entomologist of New York.

To the courtesy of Mr. Kirkland I owe the opportunity of getting over a large part of the infested territory and of making such inspections as I wished, and I have no hesitation in saying that the introduction of either or both the gypsy or brown-tail moths into New Jersey would be the greatest calamity that has ever visited the State.

As to the *gypsy moth,* its natural spread is slow, and a quarter of a century might elapse before it reached our State did it depend only on these natural powers. Unfortunately, communication by way of railroad, trolley and automobile is now so widespread that at almost any time a colony of the insects may appear at some point far removed from the present infestation. That this is not a fanciful danger is shown by the fact that egg masses have been found on freight cars and moths on passenger trains.

Since the cessation of the State work, about six years ago, the insect has extended into territory more than twice as great as that occupied by it when the work first began, and extermination seems now an impossibility. It is perhaps a question whether at least the southern half of New Jersey is not outside the climatic range of the gypsy moth, but that is not so certain as to make it a safe reliance. No present action seems desirable, but it will be well to watch developments.

As to the *brown-tail moth,* that has spread over the entire eastern section of New England, along the line of the prevailing southwest winds. It is active in both sexes, and its natural means of getting about are much greater than those of the *gypsy.* It is scarcely less destructive and has an additional offensive character in the poisonous hairs or spines with which it is covered. Fortunately, it is rather more easily dealt with in the town and orchard than the older pest, and, while a highly undesirable addition, is not so much there to be dreaded; but when it gets into the forest, while its range of food plants is not so great, its effect on deciduous trees is more severe.

A brief account of both species, taken chiefly from the Massachusetts reports and bulletins, appears in another portion of this publication.

PEAR PSYLLA.

Pear Psylla has not been much noticed of late years, but was found in some Keiffer orchards in Cumberland county this summer in harmful numbers. Late in September I found larval and pupal forms, as well as adults, and the owner of the orchard informed me that his fruit had been materially checked by the attacks of the insects. This particular orchard had never been winter-sprayed, and I advised the soluble oil in late fall. Some orchards in the same general region that were in the past injured by the *Psylla* have been free from the pest since winter spraying for scale has become necessary. That is particularly true of those cases where crude petroleum has been applied.

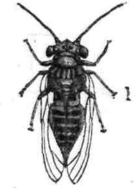


Fig. 9. The Pear Psylla. Greatly enlarged.

ROOT MAGGOTS.

Cabbage, cauliflower, radishes and onions suffer more or less each year from the attacks of *root maggots*—the first and last most severely. It happens, sometimes, that a season, or even several seasons, go by without much injury, and such period of exemption may be followed by a season or seasons of severe damage, when the insects seem to increase to such an extent as almost to prohibit the growth of the crop. On radishes the injury is usually slight, because the crop is quickly grown and quickly out of the way, so that only the first brood, from the hibernating females, can cause trouble. On cabbages the matter is more serious because of the longer period during which they are subject to attack, but cabbage-growers generally have learned how to deal with the insects by repellants, by fertilizers, by the application of insecticides or by using protective coverings. Not very much complaint of this particular species has been made of late.

The *onion maggot* has been most complained of during the two seasons last past, and from all parts of the State. Whatever the reason, complaints in past years have come mainly from the southern counties, but now all onion-growing sections are equally infested.

As against this kind of attack our remedial measures leave much to be desired; but for the information of the grower a brief life history of the species, with some account of its habits and the methods of dealing with it, is given on another page of this report.

CORNSTALK BORER.

The *cornstalk borer* was unusually abundant during early summer, and was even more troublesome in tomatoes than in corn. On looking up the literature of the species it was found that the life cycle had not yet been completely made out, and that no practical methods of control were known. The missing facts were worked out, and it now appears that by simply keeping down the natural food plants—ragweed, burdock, pigweed and the like—in September, injury can be *completely prevented.*

THE ROSE CHAFER.

After a series of years, during which little was heard of it, the *rose-chafer* (*Macrodactylus subspinosus*) has again appeared in what may

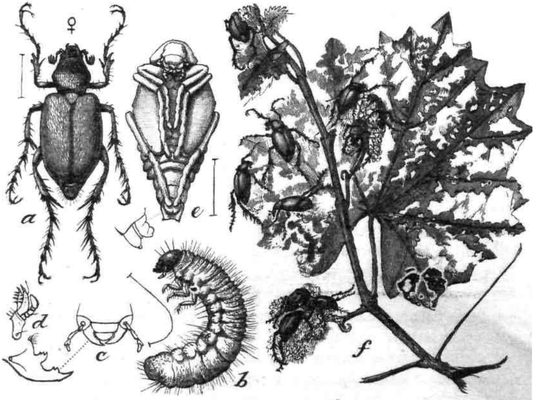


Fig. 10.

The Rose-chafer; *Macrodactylus subspinosus* Fabr.: *a*, adult female beetle; *b*, *c*, details of mouth structure; *d*, the larva; *e*, pupa—all enlarged; *f*, beetles at work on a grape leaf. From Div. Ent., U. S. Dept. Agric.

be considered injurious numbers. The species was by no means as numerous as it was in 1890, when I first became acquainted with it,

but was abundant enough to be troublesome in gardens, vineyards, and especially on apples. It was in Burlington county that I saw the insects, most commonly on young apples, but I am informed that they were equally conspicuous in other southern counties.

The matter becomes interesting from the fact that we are approaching the end of the twenty-year cycle referred to in Bulletin No. 82, issued in 1891, when the insect began to decline in numbers.

The records then made by me show that at Vineland, where my observations were carried on, the insects became plentiful enough to be offensive in 1885 or thereabouts, and they increased annually until, in 1900, the climax was reached, the vineyards having been by that time almost completely wiped out. I was then informed that a similar invasion had been observed nineteen years before, the climax coming after a four or five-year period. Most of those whose memory reached back to that time said "about twenty years ago," and the only definite date that I obtained left it open whether the year previous, making the twenty-year cycle, had not been as bad or worse. If history repeats itself, and there is really a somewhat definite period of rise and fall, the three or four years next to come will see a gradual increase of injury, culminating in 1909 or 1910.

Unfortunately, so far as methods of control are concerned, we have not advanced much since 1890.

THE ASIATIC LADY-BIRD.

The record of the experiments made with this insect during the three or four years last past was rather fully given in my report for 1904, page 575, and at this time I need only record the observations of the current year. Up to the end of September, 1904, the insects were noted in the orchard, and up to October 12th, 1904, they were kept under laboratory conditions.

May 25th, 1905, Mr. Dickerson examined very carefully that section of the Du Bois orchard in which the insects had been released, and more especially those trees on which specimens had been found feeding in 1904. No treatment of any description had been given, and the trees were quite as much infested as at any time in the past, but no trace of the *Chilocorus similis* was seen. One larva and one adult *Chilocorus* were noted, but they were out of reach and were apparently *bivulnerus*. There was not the least appearance of any feeding upon the scales in any place.

June 19th, a second examination was made, much more carefully The scales had begun to breed and new sets were already abundant especially upon the fruit. Not only was the search made by sigh merely, but branches were beaten over an inverted umbrella to reacl concealed specimens, if any. No signs of the *Chilocorus* were apparent—neither larvæ, pupæ nor adults.

It was regretfully concluded that the experiment was a failure and that the insects had failed to survive the winter.

INSECTICIDE EXPERIMENTS.

It is within bounds to say that more than 50 per cent. of all insecticide experiments result so unsatisfactorily from one cause or another that they are never recorded. A great many preparations are sent in each year, and so far as opportunity serves they are tested. But sometimes they come too late for a trial against those insects for which they are especially intended, or the insects do not appear in such numbers as to make an application conclusive. An adverse report is never made where the material has not had what I consider a fair chance, and in consequence a great deal of work goes unnoted, while the maker of the material deems the office neglectful. The truth is the Entomologist cannot afford to neglect the opportunity of getting a better or more effective insecticide than we have in our present battery, and everything that has the element of novelty in composition is investigated. In most cases flat failure results at the first trial, and the experiment closes without report; but where there is the least appearance of value the matter is carried further, even if not finally made the subject of a report. The farmer does not care to read a long series of tests of materials that prove of no use, unless they are such as are or have been offered to him in such a way as to make it important for him to know whether they are good for anything. His desire, as a rule, is to know what has been found useful and how it should be used.

It is not, therefore, a proof that a material has not been tested if no record of such a test appears. It simply means that there is nothing good to be said of it so far as the office experience goes. In the present report is given an outline of some of the results observed during the season of 1905.

WORK DONE ON THE COLLEGE FARM.

The small orchards on the College Farm are all somewhat infested with San José scale, and no radical measures were ever taken because, being under experimental culture, no applications were tolerated that might affect either a tree or its crop. An early inspection by Mr. Dickerson showed the peach and cherry plots in no immediate need of treatment; plum pretty generally infested; a scattering infestation in the apples and local infestation among the pears.

It was determined, under the circumstances, to use for most of the trees the lime, sulphur and caustic soda mixture—thirty-three pounds lime, seventeen pounds sulphur and four and one-half pounds caustic soda in fifty gallons of water, prepared without boiling. A fifty-gallon Niagara Gas Sprayer was used and the work was done April 6th, 7th and 10th, rain and other adverse conditions preventing continuous work. Hot water was used in getting the mixture in all cases, but cold water to dilute it to spraying strength. The combinations were made by or under the direction of Mr. J. A. Grossbeck; the spraying was done with Mr. E. L. Dickerson at the gas tank. The application was thorough and the wind was made use of on each day, directly and quartering. When it became necessary to spray against it, nozzles set at an angle were used, so that the men could keep out of the blowing mist.

An examination made June 22d, when the first brood of scales was in full swing, showed fairly good results. No trees appeared to have been completely cleaned, but nowhere was there more than a scattering of the larvæ apparent. Plums were yet the worst of the series, although comparatively clean.

A second examination, made July 21st, to compare more critically with the effect produced by the simple mixture of lime and sulphur, showed no worse condition of affairs and only confirmed previous conclusions. Indeed, the best method of comparing results is to say that on the peach trees, which it had not been deemed necessary to spray, more active larvæ was seen than on the treated trees.

Later in the season it developed that an error was made in neglecting the peach trees. Some of them became so badly infested as to endanger them, and furnished the prettiest object lesson of the danger of neglecting what seems a slight infestation; the sprayed trees are all in far better condition.

MISCELLANEOUS.

Three bulletins have been issued from this department since the date of the last report—No. 178, on "Insecticide Experiments for 1904;" No. 181, on "Insects Injurious to Shade Trees and Ornamental Plants," and No. 186, on "Late Fall Spraying for the San José or Pernicious Scale."

The work of the State Entomologist has been continued along the same lines as in previous years, and eighty-one certificates were issued to growers or dealers in nursery stock. Not over a dozen nursery blocks, mostly peaches, proved to be so badly infested as to be unsalable, and these were destroyed. Altogether, many thousands of infested trees were kept out of the market, and the quality of stock set out has been materially improved. Mr. Edgar L. Dickerson is still in office as assistant and Miss A. E. Meske as stenographer and office aide. A full report of the work done in this capacity will be made to the State Board of Agriculture.

The mosquito investigation has been continued on somewhat different lines, under Chapter 80, Laws of 1905, and a detailed statement of what has been accomplished forms another section of this report.

Somewhat out of line with the general scope of the department work was the investigation and treatment of the New Brunswick water-supply with sulphate of copper to control the development of algæ and other organisms that tended to cause bad smells and tastes. A special report on the results obtained, which were very satisfactory, was made to the Director.

The mosquito collection installed at St. Louis, as mentioned in the 1904 report, was transferred at the close of the fair to the State House, at Trenton, where it was set up in a somewhat different shape and material additions were made. It now forms a permanent feature of the State Museum, and as such has attracted considerable attention. A number of boxes have been made up during the year out of the office collection, to add to this Museum, which is now of considerable extent and some scientific value on the entomological side. The general collections of the office have increased greatly and large additions have been made to the storage capacity of the department.

As to equipment and general outfit, the department is in better condition than ever before, and little more can be demanded at present in the way of laboratory facilities.

Two visits were made to Massachusetts, as already stated in connection with the gypsy moth and cranberry insect investigations, and in October a visit was made to the Canadian Agricultural College at Guelph and to the Experimental Farms at Ottawa, incidental to a meeting of the Entomological Society of Ontario. The usual relations were maintained with the societies at New York, Brooklyn, Newark, Philadelphia and Washington, and a meeting of the Cambridge Club was attended in September.

Institute work during the winter and attendance at State and county board meetings and at other associations of farmers and fruit-growers has kept the department in touch with the needs of the agricultural community, so far as the insect questions are concerned, and has enabled it to direct its work accordingly.

The correspondence of the department during the calendar year of 1905 has been larger than ever before, covering 3,000 pages of letter-book and representing upwards of 4,500 individual communications. In fact, the routine work and preparing answers to questions has come to occupy so large a proportion of the available time as to trench seriously upon the necessary investigation work.

ENTOMOLOGY IN THE CROP BULLETIN.

Twenty-three numbers of the Crop Bulletin were issued between April 11th and September 12th, 1905, and in all save three of them insects of some kind were recorded as injurious.

The *San José scale* was first referred to and held the record throughout the season. April 11th the recorder summarizes as follows: "The outlook for orchard fruit is fairly good except in orchards where the San José scale is prevalent. In places in Mercer county many trees have been killed by this pest. Much spraying—more than ever before at this season of the year—has been done." On the 17th, two localities in Hunterdon county report the continuance of orchard spraying for this pest. April 25th, Plainfield, Union county, and Canton, Salem county, refer to the fact that the scale is infesting their fruit trees. May 2d, South Bound Brook, Somerset county, notes an increase in the numbers of this species. May 9th, Newton, Sussex county, notes that there had been "some plum trees killed by the San José scale." May 23d, the scale was killing "many trees" at Paterson, in Passaic county, and on the 30th only trees sprayed for

scale were doing well at Pottersville, in Somerset county. Not until August 29th is there another record, and then at Rowland's Mills, Hunterdon county, the "San José scale is doing great injury to the apple trees in this vicinity." September 5th, "San José scale prevalent" is reported from Merchantville, in Camden county, and in the last bulletin of the season, September 12th, San José scale was increasing at Sussex, in Sussex county; and from Basking Ridge, in Somerset county, we learn of many apple trees killed, while peach trees in the vicinity of Mine Brook had been kept in good condition by spraying.

Cut-worms were first referred to in the bulletin for May 16th, from Woodbury, Gloucester county, and May 23d had become quite numerous and destructive to corn and lima beans. Records also came from Flemington, Hunterdon county; Bridgeton, Cumberland county; Beverly and Moorestown, Burlington county, and Mickleton and Woodbury, Gloucester county. Even more numerous and from a greater range were the complaints on May 30th—cabbage, tomatoes and other vegetables being added to the crops injured. Specifically, reports came from Paterson and Charlotteburg, Passaic county; Delaware and Phillipsburg, Warren county; Moorestown, Burlington county; Berlin, Camden county; Bridgeton, Cumberland county; Woodstown, Salem county; Cassville and Toms River, Ocean county, and Dias Creek, Cape May county. June 6th the records had somewhat decreased in number and were chiefly from the more northern sections—Sussex and Fredon, Sussex county; Warrenville, Somerset county; Three Bridges, Hunterdon county; Imlaystown, Monmouth county, and Berlin, Camden county. June 13th was almost a repetition of the previous week, but cornfields especially seem to have suffered; Newton, Sussex county, reports entire fields destroyed, while Sussex and Layton, in the same county, make similar statements. Pittstown, Hunterdon county; Kingston, Somerset county, and Hazlet, Monmouth county, represent complaints from the central section, while Berlin, Camden county, is the only one of the southern section that reports them still numerous. June 20th the worms were yet very destructive to corn at Fredon, Sussex county, and that was the only report for that date. June 27th, Rowland's Mills, Hunterdon county, reports corn a very uneven stand, due to cut-worm injury. July [illegible], a belated report from Moorestown, Burlington county, represents "cut-worms unusually destructive," and the last report is under date of August 1st, from Charlotteburg, Passaic county, stating that "cut-worms injured cabbage early in the season."

Potato bugs were first reported May 16th, from Warrenville, Sussex county, where they were "just beginning to appear;" Woodbury, Gloucester county; Marlton, Burlington county, and Bridgeton, Cumberland county, where they were already numerous and destructive. May 23d, Beverly, Burlington county; Woodbury, Gloucester county, and Canton, Salem county, report trouble and complaints of injury. May 30th, reports of injury came from Kingston, Somerset county; Berlin, Camden county, and Cold Springs and Cape May, Cape May county. June 6th, records were mainly from up-state—Charlotteburg, Passaic county; Warrenville, Somerset county, and Cranford, Union county. June 13th, only Layton, Sussex county, marks them as "destructive." June 20th, only Charlotteburg, Passaic county, and South Bound Brook, Somerset county, were having trouble, while on the 27th only Newton, Sussex county, reports "potato bugs very destructive," and that is the last record for the season.

Asparagus beetles were first reported as numerous May 23d, from Bound Brook, Somerset county, and on June 20th they were injuring young patches at Hazlet, Monmouth county. The third and last note comes from Cold Springs, Cape May county, where, on July 25th, the beetles were "very destructive."

Root maggots were unusually troublesome both on onions and cabbage, and some of this is reported. The first item is from Bridgeton, Cumberland county, where, on May 30th, the *onion maggot* was "very destructive." June 13th, the same insect was "bad in places" near Rancocas, Burlington county, and on the 20th it was "very destructive" at Farmingdale, Monmouth county, a statement which is repeated July 5th. June 27th, the *cabbage maggot* was reported from Hazlet, Monmouth county, and on August 8th, Moorestown, Burlington county, states that the injury to cabbage is "very severe."

Rose-bugs were first noted at Rancocas, Burlington county, destroying grape buds. June 20th and July 5th, Paterson, Passaic county, reports "much," and Vineland, Cumberland county, "slight," injury to vineyards. In view of the fact that this insect appeared in greater numbers than for many years past, this is a very scant record.

Among other insects that appeared locally or attracted attention only once is the *currant worm,* which was reported May 23d from Bergen Point, Hudson county, though it actually occurred more or less throughout the State. So the *Aphis* on peach trees, reported at

the same time from the same place, was almost universally distributed, though it did little or no injury. *Wire-worms* were reported as cutting corn badly at Woodstown, Salem county, May 30th, and were not later referred to. *Squash bugs* were "numerous" at Cold Springs, Cape May county, May 30th, and this seems to have been rather exceptional, because I did not see them anywhere in my trips in any numbers. "Bugs" on sweet potatoes were reported once only, from Berlin, Camden county, June 6th, and the tortoise beetles, or their larvæ, the peddlers, were probably intended. So, when Goshen, Cape May county, sets out, under the same date, that "melon vines are being destroyed by insects, necessitating the replanting of some entire fields," it is probable that the *striped beetle* was at fault, though it may have been *cut-worms*. Under date of June 20th, South Bound Brook, Somerset county, reports the "*grain moth* more numerous than for several years," but nothing that indicates a general increase has yet come to hand.

June 27th, Titusville, Mercer county, claimed that "a worm similar to the *potato stalk-borer* is doing much damage to tomatoes and corn," and while this is the only reference to the matter in the Crop Bulletin, a great deal of injury was actually caused in many localities, especially in gardens. Finally, "*grasshoppers* quite numerous in places" comes from Rowland's Mills, Hunterdon county, August 15th, without any statement that any harm was done by the insects.

THE GYPSY MOTH.

Porthetria dispar Linn.

The gypsy moth is a well-known European insect, which was introduced into Massachusetts in 1868 or 1869 by the naturalist, Leopold Trouvelot, who was then engaged in a series of experiments with silk-producing caterpillars, native and exotic, hoping to find a substitute for or a supplement to the Chinese silk-worm. In some way this particular species escaped from confinement and established itself outdoors, under natural conditions. Although this fact was at once made public, it attracted no especial attention and the spread was at first very slow. It was not until 1889 that there was any extensive outbreak, and then it was found that the insect had gained a foothold in thirty townships, all adjacent to each other. In the elaborate report on

this subject, published in 1896 under the direction of the State Board of Agriculture by the State of Massachusetts, Mr. Edward H. Forbush, field director, gives a full account of its early spread, the individual efforts to check its ravages and the reasons why in so long a period so little spread had been made.

The conditions in the worst infested districts are described as follows: "The number of caterpillars that swarmed over certain sections of the town during the latter part of June and most of July, 1889, is almost beyond belief. Prominent citizens have testified that the 'worms' were so numerous that one could slide on the crushed bodies on the sidewalks; and that they crowded each other off the trees and gathered in masses on the ground, fences and houses, entering windows, destroying flowering plants in the houses and even appearing in the chambers at night. The huge, hairy, full-grown caterpillars were constantly dropping upon people on the sidewalks beneath the trees, while the smaller larvæ, hanging by invisible threads, were swept into the eyes and upon the faces and necks of passers. The myriads that were crushed under foot on the sidewalks of the village gave the streets a filthy and unclean appearance. Ladies passing along certain streets could hardly avoid having their clothes soiled, and were obliged to shake the caterpillars from their skirts. Clothes hanging upon the line were stained by the larvæ which dropped or blew upon them from trees or buildings. In the warm, still, summer nights a sickening odor arose from the masses of caterpillars and pupæ in the woods and orchards, and a constant shower of excrement fell from the trees. The presence of this horde of gypsy moth larvæ had become a serious nuisance and was fast assuming the aspect of a plague."

It should be explained here that, unlike most other caterpillars, that of the gypsy moth is almost omnivorous, feeding upon conifers as well as deciduous trees, and upon field crops as readily as upon roadside shrubs and weeds—practically nothing comes amiss.

So serious was the matter deemed that in 1890 the Legislature appropriated $25,000 "to provide against depredations by the insect known as the *Ocneria dispar*, or gypsy moth." In 1891 an additional appropriation of $50,000 was made; in 1892, $75,000 was provided; in 1893 the sum was increased to $100,000; in 1894 a similar amount of $100,000 was made available; in 1895 another increase brought the amount up to $150,000. Thus, up to the date of the report already referred to, just half a million dollars ($500,000) had been

expended by the State, and a very large sum in addition had been paid by individual owners in sections which the State forces had not yet reached. Between 1896 and 1900, when the last appropriation was made, $674,000 additional was provided, the sums reaching $200,000 in 1898 and 1899. With the appropriation for 1900 the work ended, and the statement of Mr. E. H. Forbush, field director, before the Association of Economic Entomologists, in the summer of 1899, gave a comprehensive review of what had been accomplished up to that time. February 1st, 1900, is the official date when the work was discontinued, and since then the State has done nothing, while Nature has moved on, slowly but surely, according to her own methods.

The *status* of the matter in Massachusetts at the present time is, therefore, that the State has expended $1,174,000, while the work of attempted extermination was carried on; that there has been expended since that time, by municipalities, not less than $60,000 annually, or $240,000, and by individuals $100,000 annually, or nearly half a million. Since the stoppage of the work in 1900 the insect has not only regained all its old ground, but has spread over additional territory, double in area that which it held at first. The money already spent is absolutely wasted because the work was discontinued when success was almost at hand!

My first visit to the gypsy moth district was in 1893, and my impressions at that time were recorded in a note to Dr. C. H. Fernald, the entomologist of the committee carrying on the work. This note is published in the report of 1896, on page xxxvi. of the appendix. My next visit was in the winter of 1897 (January), and my report on that visit, made to the Society for the Promotion of Agriculture, was never published.

The insect has again become so threatening and has again caused so much actual injury that the Legislature of Massachusetts has passed another law, providing for a fight against it on new lines and carrying an appropriation of $330,000, with an added obligation upon municipalities of practically twice as much, bringing the total contemplated expenditures during two years next ensuing up to the sum of over $900,000.

It needs no apology for presenting this record here if there is the least danger of introducing so injurious and expensive an insect into New Jersey, and my visit to the infested district in August has convinced me that while the danger is not at present imminent, it may

at any time become so. It is well, then, to know something of the insect, its appearance in all stages, its life history and the manner in which it is spread.

Appearance of the Insect.

The gypsy moth belongs to a family or group allied to our common vaporer moth, and the male is not unlike it in general appearance, except that it is fully twice as large. The fore-wings are smoky-brown, with a yellowish tinge, and crossed by *four undulating, blackish bands;* the hind-wings are more uniformly dull, dark yellow. The antennæ or feelers are broadly feathered and conspicuous. This moth is active and flies readily, though not strongly, seeking the females in daylight as well as during the evening.

Fig. 13.
Male Gypsy Moth. From Div. Ent., U. S. Dept. Agric.

The female is decidedly larger and is a more heavily-built insect throughout. In color it is whitish, with a dirty, yellowish tinge, and the fore-wings are crossed by irregular blackish lines, which are much more distinct along the upper or front margin. There *are also two black* spots on the disc, so that when the insect is seen at rest on a tree trunk it has the form of an elongate triangle with apex up, and along each lateral margin a series of short, black lines, which fade out as they approach the middle. The abdomen is covered with yellowish hairs and scales, which are more dense toward the tip.

Fig. 14.
Female Gypsy Moth. From Div. Ent., U. S. Dept. Agric.

This female is sluggish and rarely flies. If she drops to the ground she may crawl to and on a tree trunk; but she is just as likely to crawl under a stone or on any other convenient foothold. Wherever she fixes herself she awaits the male, and after impregnation begins to lay her eggs.

Egg-Laying.

Egg-laying begins during the last week in July and continues for nearly a month thereafter as adults mature, for some egg clusters begin to appear before the caterpillars are pupating generally, and a few larvæ may yet be found in the fore part of August, when egg masses are already abundant. I saw two females ovipositing September 20th.

These egg masses are oval or rounded clusters containing from 400 to 500 eggs on an average, and they are covered with yellowish hair from the body of the female, giving them a characteristic appearance like a small piece of sponge. These masses are deposited in every conceivable place—on the trees, on the ground, under stones, in or between fence rails or stone fences, and in fact wherever a female emerged in a shelter large enough for a caterpillar to crawl into. As a rule the eggs remain unhatched until the next season, except that in long, warm autumns a small percentage hatch; but the larvæ so produced fail to come to maturity.

Normally eggs hatch at any time between the end of April and the middle of June, depending upon the amount of warmth received.

Larval Development and Habits.

When first hatched the caterpillars are about .14 of an inch in length, pale, brownish yellow in color, with a shining, black head. As they grew there is some change in appearance, and from four to seven moults or stages have been observed, the females requiring a longer period of development than the males. When full grown the caterpillar is from two to two and a half inches in length; the head dull whitish, mottled with brown and black; the body dull grayish, varying to blue or greenish, with bluish dorsal spots nearly to the middle and reddish spots behind that point to the anal end. From the tubercles on the segments are tufts of long, thin, but not very conspicuous hair. As the larva is figured herewith, no further words of description would seem to be needed.

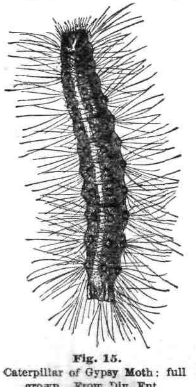


Fig. 15.
Caterpillar of Gypsy Moth: full grown. From Div. Ent.

When ready for the change to the pupa the caterpillar is apt to wander from its

distance, in search of a place to pupate. Not that it is at all particular in regard to location, for any old place will serve; but this seems to be one of the provisions for the distribution or spread of the insect, to make up for the sluggish habit of the female. Where the caterpillars are abundant they often pupate in masses, so that hundreds of them may be found in an angle or crevice, or in a narrow space. They spin a few threads as a support—the merest apology for a cocoon—and then change to a brown, cylindrical pupa, blunt at the head and tapering to a point at the tail. In this stage the difference between the sexes is very noticeable, the pupa of the male being much the smaller, and having the antennal case broad and showing the characteristic pectinations. This stage lasts about ten days, a maximum of fourteen and a minimum of seven, representing the observed extremes.

Fig. 16.
Pupa of Gypsy Moth in loose cocoon.
From Div. Ent., U. S Dept. Agric.

As a rule the caterpillars feed at night and hide, or at least remain quiet, during the day. It is therefore quite possible to see the trees stripped, and yet at first see nothing of the insects that did it. In the early stages the little caterpillars spin readily and have the habit of suspending themselves by a thread. A sudden jar or alarm may also cause them to let go of their support and drop for a longer or shorter distance.

Methods of Spread.

Emphasis has been placed upon the fact that the female moth is no traveler and that under natural conditions the wandering habits of the caterpillars in the later stages provide for a limited extension each year. Accidental carriage of eggs, or even of adult females, by birds or other animals, comes within the range of possibility, and young caterpillars may be carried off for some distance. But these natural methods are very tedious, and the infested territory would extend but slowly were they alone to be considered.

Unfortunately the human element comes into the problem, and thus a spread of hundreds of miles in a year is among the possibilities. While the larvæ are small and suspend themselves readily by threads, many of them are carried away by pedestrians walking beneath the trees. When the insects are discovered the natural tendency is to brush them off to get rid of them, no matter where or how far away from the place where they were gathered. When they fall upon carriages, wagons or similar conveyances, the distance to which they may be carried is much greater, and on a trolley car the range is yet more extensive. Yet even the trolley range is a limited one and confined to a definite line. Railroad trains do not often travel on a line overshadowed by trees, so these are not so greatly important. Automobiles, however, go everywhere, and may carry young caterpillars for many miles in a single day. If at the end of a day's run the young larvæ find food convenient, and are in sufficient number to have both sexes represented, a colony may be established. No doubt many individuals have been so carried, have developed and have died for lack of a mate. It is only by a fortunate combination that a reproductive colony can be established in this way, but this combination may happen at any time, and perhaps has happened, for the present outer limits of infestation are by no means established.

When the full-grown caterpillars wander along the line of a railroad the danger becomes much enhanced. Freight cars on sidings, cordwood to be loaded and carried away, boxes, bales, barrels, crates and other carriers serve as excellent places for pupation, and from a single pair carried off in this way a colony could readily be established miles away. That this is not a remote contingency is shown by the fact that moths and egg masses were observed in some numbers on a railroad station building in the infested district, and freight cars were observed on sidings close to infested trees.

The danger of rapid spread increases as the infested area increases, and it is greater now than it has been at any time since the insect has established itself in this country.

At present the probability of an early spread to the New Jersey line is slight; the possibility exists of entrance through the medium of freight, freight cars or plants from the infested districts. Much now depends upon the amount of work that can be accomplished next winter under the new law in Massachusetts.

Danger to New Jersey?

In a careful study of the life history of the gypsy moth, the question arose: Assuming that the insect is introduced into the State, can it maintain itself here? As to the more northern sections, in all probability, yes; as to the region south of the red shale line, in all probability, no.

Dr. Fernald's careful study of the life history and development of the gypsy moth proves to demonstration that the matter of egg development is almost entirely a question of temperature. As soon as the spring temperature rises sufficiently, the eggs hatch—those in the warmest places first, the others as the general temperature rises. The egg masses formed in early August are, of course, subject to the same general laws of development. They are normally intended to pass the winter in that condition, and development of the embryo proceeds slowly. As the average temperature decreases through longer, cool nights, development is checked, proceeds more slowly, and soon ceases altogether until resumed under the influence of the spring sun. Yet, if the average temperature continues sufficiently high, development will continue, even to the hatching of the eggs, as was found in the season of 1895, at Woburn, Mass., where an unusually warm period in late August and early September induced the hatching of a large percentage of the eggs. None of the larvæ of this late hatching reached maturity.

Now, the climatic conditions in New Jersey south of the red shale line are just those of the unusual conditions of 1895, and we are entitled to conclude that the effects on the insects would be similar. In other words, assuming that a colony were established anywhere in Burlington county, it might develop normally until the eggs were laid in late July, but then the high average temperature of August and early September would induce these eggs to hatch, and long before the larvæ would come to maturity the food supply would be cut off or lessened to such an extent that none of them could develop.

As to the question that has been asked: Can we do anything to prevent introduction of the insect into New Jersey? the answer must be, no. It is possible, however, to keep a close lookout and to be in readiness to stamp the species out should it succeed in forming a colony. On that point the Department expects to keep itself posted, but it is dependent largely upon information that comes from those especially interested in trees or parks.

As to the methods of fighting the insects, nothing need be said here at present.

NOTE.—On the matter of climatic conditions, Mr. E. W. McGann, of the New Jersey State Weather Service, furnishes the following data: The mean August temperature for Boston is 68.5°; the mean temperature in 1895, when a partial second brood appeared, was 71°, or 2.5° above the normal. Early September also showed unusually high temperatures, but they did not continue. In New Jersey only the extreme northern stations report normals as low as that of Boston, while most of them, even north of the red shale line, report normals exceeding the exceptional Boston record of 1895. Those given by Mr. McGann are: Dover, Morris county, 71.9°; Deckertown, Sussex county, 71.2°; Boonton, Morris county, 73.2°; New Brunswick, Middlesex county, 72.6°; River Vale, Bergen county, 71.4°.

This would indicate that even in northern New Jersey there would be a tendency for the hatching of the summer eggs and a corresponding natural check to gypsy moth increase.

THE BROWN-TAIL MOTH.

Euproctis chrysorrhœa Linn.

This is the other of the species that has been introduced into Massachusetts within recent years, scarcely second to the gypsy moth in destructiveness, while more annoying than that insect because of the fact that the hair or vestiture covering the caterpillar is more or less poisonous in the later stages. According to the reports of Dr. C. H. Fernald, from whose writings much of the information here given is obtained, the insect was first reported in this country in Somerville, Mass., in the spring of 1897, and careful inquiries revealed the fact that it had been observed by some of the residents of that locality for at least five years. In the center of the infested region is a florist establishment, where, previous to 1890, roses and other shrubs were imported from France and Holland, and it seemed very probable, from all the facts obtained, that the brown-tail moth was accidentally introduced on some of these plants as early as 18[illegible].

Mr. A. H. Kirkland, writing several years afterward, puts the matter in a somewhat different shape. In a paper before the Association of Economic Entomologists, in June, 1900, he makes it: "Area infested in the fall of 1896, twenty-nine square miles; fall of 1897, 158 square miles; fall of 1898, 448 square miles; fall of 1899, 928 square miles. In the course of my visits to

the infested region, in August and September, 1905, I found that the insect then covered almost the entire State of Massachusetts, had extended into and through New Hampshire, covered a large part of Maine and had even crossed the border into New Brunswick. There has been comparatively little spread to the east and to the south because the prevailing winds in New England during the summer are from the south to southwest, and these determine the direction of distribution for the insect."

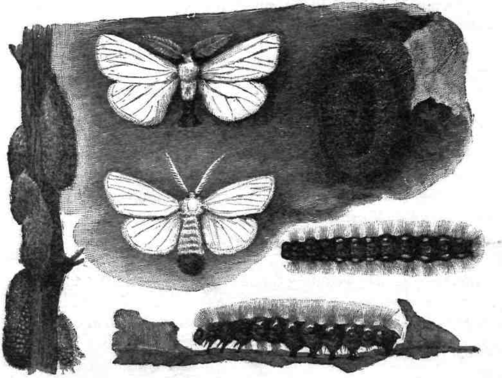


Fig. 17.
The Brown-tail Moth, *Euproctis chrysorrhoea* Linn.: male moth above, female below, eggs at left, cocoon at right, larvæ below at right. From Howard, Div. Ent., U. S. Dept. Agric.

In the brown-tail moth both sexes are capable of flight, but they are not very active or strong fliers, and rather drift with the wind than attempt to fly against it. Nevertheless, each year sees a spread even against the prevailing direction of the wind, and there seems to be no reason why this insect should not, in the not too distant future, spread over into the Middle States. It is approximately correct to say that it already infests almost or quite the entire New England district.

What may happen in even a single season is recorded by Professor Fernald in 1898. At the time that the species was first discovered as being present in considerable numbers, the area in which serious damage had been done was nearly circular in outline, with a diameter of about a mile, and the flying season, which is of limited duration, was at hand. It was exceedingly fortunate that a severe gale of wind occurred at the height of this season in 1897, which distributed these moths for a distance of ten or twelve miles to the north and northeast. Records are given showing the direction of the wind during the day, a matter which is of little importance in view of the fact that the insects fly only at night; but the records of the night wind directions correspond perfectly with the observed distribution of the insects during the next season.

In Europe the moth occurs almost everywhere, except in the extreme north, and extends to Morocco, Algeria and Asia Minor. In Great Britain it was formerly much more abundant than it is at the present time, and so far as records go it is never injurious to cultivated crops. There is nothing in the history of this insect that leads to the belief that it is not quite capable of maintaining itself throughout the entire Northern Atlantic States, and, of course, including the entire State of New Jersey.

As to its food plants, it lives on a great variety of both wild and cultivated plants, including all the ordinary orchard fruits and most of the common forest trees. Its favorite is perhaps the pear, among the orchard fruits, and such trees will be covered with webs where neighboring apple trees will be comparatively free.

Life History.

The moths are on the wing about the middle of July, and each female lays from 200 to 300 eggs in an oblong cluster on the under side of the leaf, near the end of a branch, covering them with a dense mass of brown hair from the tip of the abdomen. The moths expand from an inch to an inch and a half, the males being the smaller, and are pure white in color. In the female the abdomen is much larger than it is in the male, and at the tip of both there is a round, dense tuft of brown hair, which gives the common name "brown-tail" to the insect. The moths are attracted to light, and I have seen photographs made of an electric light pole with the insects so densely clustered

upon it that there was scarcely room for another. So conspicuous are they that they are readily noticed, and their presence is easily determinable. The eggs hatch early in August, and the young caterpillars feed only upon the surface of the leaf, causing them to turn brown, as if they had been burned, somewhat like the effect produced on elms by the work of the larvæ of the elm-leaf beetle. The caterpillars also attack the fruits of the apple and pear. While still young they make a regular dwelling, in which they hibernate during the winter. This is constructed at the ends of the twigs, and made by drawing together a few leaves, lining them with silk and surrounding them with a mass of silken threads. They are thus rather conspicuous, and so firmly are the tents fastened to the twigs that they can rarely be removed without using considerable force. The young caterpillars cease feeding and retire into these tents late in September, and there they remain during the winter in a sort of half dormant condition. They become active again about the middle of April, or with the opening out of the new foliage, and feed upon the buds—in some cases even before the leaves have actually unfolded. When feeding upon the foliage they devour everything except the midrib, or, in leaves in which the veins are strong, they leave the entire skeleton, giving the tree a very curious appearance. When the caterpillars are numerous they devour not only the buds, leaves and blossoms, but even the green fruit, feeding continuously until early June; then they spin an open cocoon of coarse silk among the leaves, where they have been feeding, and transform to the pupal stage. They remain in this condition about a month, and then the moths emerge to begin again the life cycle which was started with their appearance. There is therefore only a single brood; but caterpillars appear twice, and where the insects are numerous there may be a defoliation of the trees in spring by the hibernated larvæ and again in the fall by those that hatched after midsummer.

Irritation Caused by Hair.

The caterpillars of this brown-tail moth are clothed with hairs that produce a poisoning or "nettling" effect when applied to the skin. From experiments made under the direction of Dr. Fernald, it seems very certain that there is no real poison involved, but the hair, when examined under the microscope, appears barbed and set with small spurs or processes, which break off very readily. When a few of these hairs are placed on the skin and rubbed lightly the small barbs break,

enter the pores and produce an irritation that is intensely annoying to most people and seriously troublesome to others—so troublesome, indeed, that the services of a physician are frequently required. It is not until the insects become nearly half grown that difficulty is experienced; but after that time, where the insects are plentiful, the air is likely to become filled with hairs when the caterpillars molt or change their skins, and when they pupate and spin their cocoon the loose hair is sometimes carried to considerable distances. It is quite possible, therefore, that without handling the caterpillars, or without even coming very close to them, an individual may become the victim of this nettling effect. When the hairs get into the eye a very troublesome inflammation is set up, and this, in most cases, requires the attention of a physician. In speaking with Mr. Kirkland about this matter, he referred to several cases where intense suffering and high fever were produced, and there are some cases in which death was the indirect result. As to the remedial measures employed, they are much the same as those in general use for plant nettling or for ivy poisoning.

This peculiar characteristic puts the brown-tail moth in a class by itself, and makes it really a nuisance to the community in which it occurs, as a menace to public health. Irrespective, therefore, of the injury that is caused to trees and other vegetation, the species is an undesirable one from every other point of view.

As to the methods of spread, it has been already shown that the insect flies, and that therefore it is not so dependent upon outside means of transportation for its distribution. Nevertheless, almost all of the methods by which the gypsy moth may travel may serve to distribute this species as well. Railroad trains are likely to play a great part in its spread, because if a fertilized female concealed herself during the day on a freight or passenger coach, the next evening may find her hundreds of miles away and in condition to take flight and start a colony.

THE WHITE-MARKED TUSSOCK OR VAPORER MOTH.

Orgyia leucostigma S. & A.

This insect shared with other shade-tree pests in the conditions favorable to insect development and became extremely abundant throughout a large section of the State. Although it is not really particular as to its food, maples were, as a rule, more infested than

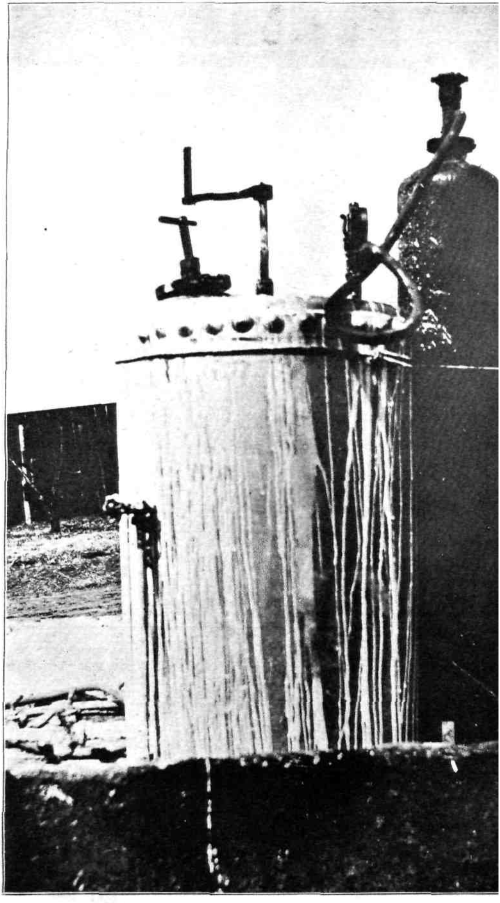


Fig. 11.
The 50 gallon Niagara Gas-sprayer in use on the College Farm; with two leads of hose
From an original photograph.

Fig. 12.

Plum orchard on the College Farm sprayed with lime, sulphur and soda. From an original photograph.

anything else save poplar, and the silver or soft maples were more hardly dealt with than any other variety. Injury became obvious quite early in the season, and the caterpillars were so unpleasantly conspicuous in many places that public attention was drawn to them and the question of abatement arose. In some places where organization existed spraying was resorted to, and while at no point were the insects entirely cleaned out, they were, at any rate, kept in severe check. At most places, however, the first brood matured, and when the cocoons and egg masses appeared attempts were made to gather and destroy them. The experiment made in Newark of purchasing egg masses is elsewhere referred to, and points out a practical method of dealing with the insect in midsummer and preventing or materially checking the development of a second brood, or, where no second brood occurs, of lessening the supply for the season following.

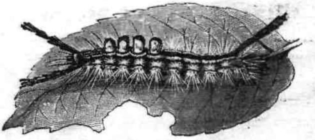


Fig. 18.
Caterpillar of the Tussock Moth. After Riley.

On this latter point it was found that the State is divided into two rather well-marked faunal regions. Egg masses obtained at Riverton during the early days of August hatched promptly, and the second brood of caterpillars was large. But from dozens of egg masses collected at New Brunswick only a scant hatching was obtained: by far the greater number of masses remained undeveloped, although the eggs, on examination of the undeveloped masses, proved entirely sound. The prompt collection of midsummer egg masses is therefore a much more important matter in the counties south of the red shale line than it is at New Brunswick or points further north, where the second brood is fragmentary or non-existent.

At Newark and in the immediately surrounding towns a curious condition exists. In some parts of the city all the eggs hatched and there was a full second brood; in others none hatched, and the late brood was altogether absent. In the suburbs, anywhere from none to 75 per cent. of the eggs hatched, and even the eggs of one cluster varied. In some clusters every egg was hatched; in others a varying percentage developed; in yet others all the eggs remained sound. Part

of Newark is really in a little extension of the upper austral zone, while to the north, west and southwest the transition zone, with only well-marked brood, obtains.

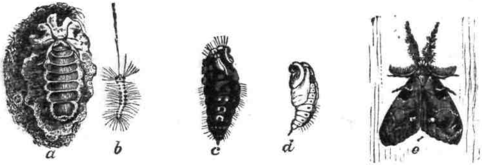


Fig. 19.

The White-marked Tussock Moth: *a*, the female ovipositing on the empty cocoon; *b*, young caterpillar suspended by a silken thread; *c*, pupa of female; *d*, pupa of male; *e*, male adult or moth. After Riley.

In many places sticky flypaper and other bandings were resorted to, to keep off the caterpillars or to prevent their increase, but in most cases without effect. Sticky bands are good and effective only if the trees are entirely free from egg masses, and if they are applied *before* the caterpillars hatch from the egg masses in the near neighborhood. Applied after the caterpillars are already feeding, it simply compels them to pupate above the band, and that is where the egg masses will then be formed. The whole theory of banding rests upon the fact that we have a clean tree to begin with, and the attempt is to keep outsiders from getting to the foliage.

Where there is an organization sufficient to keep one or two good men going all winter, an enormous number of trees, not too badly plastered with egg masses, can be thoroughly cleaned, and if, then, early in the season these clean trees are banded well up on the trunk, it will prevent caterpillars that may hatch from egg masses concealed on nearby fences and other shelter from getting to the foliage. It would seem to be almost unnecessary to call attention to the importance of gathering the egg masses on the fences, railings and buildings near trees that have been infested; but I have seen trees carefully cleaned and dozens of egg masses left on the railings and staircase of a closely adjoining building. The young caterpillars are not bad travelers and can live without food for a day or two after hatching. Where numerous egg masses occur on large trees it will cost very heavily to clean up, and several sprayings in summer are much cheaper; but where

the infestation is not heavy, most of the egg clusters are well down on the trunk and branches, and can be easily reached.

Winter work, then, against this insect should be practiced as far as possible, leaving the growing season free for dealing with other pests that can be reached at that time only. Small boys, employed to collect egg masses at a fixed rate per measure, would prove useful in reaching the more obvious material, leaving to the careful inspector the task of finding the less obvious or more inaccessible clusters. There seems to be no real reason why thorough work for a year or two should not result in the almost complete elimination of this insect.

Quite a number of parasites were bred from material gathered at New Brunswick, but from some information gained in Massachusetts, it is a question whether almost half of these parasites were not really secondary. In any case the percentage of parasitism was not sufficiently great in 1905 to keep the insect down to normal limits. Outside of cities and towns it was rarely met with.

CRANBERRY OBSERVATIONS.

The question has been asked, at times, how late in the season water should be held on a cranberry bog to destroy the eggs of the black-head (*Eudemis vacciniana*)? This is a matter of great practical importance, and yet it has not been possible to answer it heretofore with any degree of definiteness. We know that the eggs may hatch on exposed vines before even a start is made, and I have found the young larvæ dead, in leaf tissue, when water was drawn from a bog by the middle of May. In general, my recommendation has been, hold as long as you dare without risking injury to the crop. On badly-infested bogs water has been held as late as June 1st, with absolute success as against the insect, but the practical loss of the crop.

At the discussions before the American Cranberry Growers' Association, at its winter meeting, January, 1905, it appeared that late holding did not produce exemption during the preceding summer, and that many bogs were seriously injured. But it appeared, also, that the species at fault was the yellow-head (*Teras minuta*), which hibernates as an adult and lays eggs in spring. Late holding in this case, therefore, means only preventing access to the vines until the moths have laid their eggs elsewhere. Further inquiry developed the fact that while the season was unusually late the water was drawn at about

the usual time, and, also, that sections of bogs not entirely covered by water were first and most seriously infested, later broods starting from these centers.

The explanation was simple enough with *all the facts* at hand. The moths remained dormant a week or ten days later than usual, and when they were ready to oviposit the bogs were wholly or partly bare. The highest vines were cleanest and most nearly ready to start, hence were selected by preference. Drawing, therefore, should not be wholly by date, even if the yellow-head only is aimed at; but it should be at a date when nature has reached a normal May 1st period. Oviposition *usually begins before the middle of April, and by the 1st of May* well-advanced larvæ may be found, the hibernating adults themselves having disappeared.

Water temperatures do not enter into this *Teras* problem at all, but the matter is different with the black-heads, where the eggs hibernate on the leaves. We know that these eggs hatch on exposed vines before the water is normally taken off, and larvæ may make their appearance on flooded bogs a few days after the water is drawn. The problem here is to discover the hatching temperature and how long the egg must be submitted to it before the larva develops under water—if it develops at all.

To ascertain these points a series of observations was planned, including temperature records on the water covering the bogs. Mr. I. W. Budd, of Pemberton; Mr. A. J. Rider, of Hammonton, and Miss Elizabeth C. White, of New Lisbon, agreed to co-operate, and under my immediate direction Mr. E. L. Dickerson, my assistant as State Entomologist, was to make observations at Jamesburg. And then began the chapter of accidents! It was found, when the thermometers were ordered, that none adapted for taking water temperatures at varying depths were carried in stock, and they had to be especially made. When completed, some failed to work on receipt and others were broken in transit, so that it was not until April 19th that any records were made. Fortunately this proved to be early enough, because the air temperatures could be supplemented by the records of the State Weather Service, and the relation of water to air temperature appears fairly from the records made.

MR. THAYER'S NOTES.

Mr. Henry J. Thayer, of Boston, Mass., proprietor of the Indian Head cranberry bogs at Plymouth, Mass., was present at the Cranberry meeting in January, and he was good enough to supply me with a series of temperature observations made on his bogs, from which he drew the following conclusions:

First. That the fierce heat of the sun is (almost) entirely dissipated within two or three inches of the surface of the water and greatly diminished at even one inch.

Second. Between depths of four inches and twenty inches the temperature of the water is (practically) the same, and shaded portions do not differ materially from those exposed to direct sunlight.

Third. Below twenty inches the direct heat of the sun is lost, and rise and fall of temperature corresponds to the seasonal change in the warmth of the earth.

Fourth. A daily rise in temperature occurs within twenty inches of the surface, whether the day is cool or hot, clear or cloudy, and the daily range is nearly as great on an ordinary cloudy day as under a clear sky and hot sun.

Fifth. Even under an ice covering a daily change in temperature occurs.

Sixth. Sharp extremes of day and night temperatures somewhat affect the following daily record, but not to any very great extent, and the changes that do occur are more in the nature of a seasonal than of a daily or weekly change.

In a general way, these conclusions have been borne out by the records received. At from three to four feet there was a constant increase of temperature from a minimum of 46° on April 19th, to a maximum of 64° on May 10th, though the outdoor temperature ranged in the same period from 23° to 84.5°. Many things had to be considered in making the records and in drawing conclusions from those that were made, for no two bogs are alike in exposure, in the source of the water-supply and in the amount of flow in the water-body. The effort was to get at conditions as they existed in a practically permanent water-body without a definite channel or current through it. The larger the body of water the more uniform its temperature; and where the supply to keep up the head came from a reservoir or large storage area, it was more uniform than where it was

derived from a large stream. In a current the water was always two degrees colder than in a stagnant area, and a shallow had as great an advantage over a deep pool. Where one foot was the depth of the water, the temperature at that depth was from two degrees to four degrees higher than at one foot, with three or four feet of water as the depth of the pond. At a gate the water was always a little lower in temperature at the same depth than in any other portion of the bog. Temperatures taken in the swamps and ditches from which the bogs were supplied were like those at three feet depth, and may be considered the ground warmth. They varied little, no matter what the air temperature might be. Locality had little effect on the deep water. May 6th, the Jamesburg, White, Budd and Rider bogs varied less than two degrees at three feet, and very little more at the surface. The records are not entirely comparable, because the dates on which observations were made were not identical; but here the records of the State Weather Service are brought into comparison, and the intervening dates are filled in from Hightstown, which is only a few miles from Jamesburg, and Lakewood, which is in a territory similar to the other bogs. Surface temperatures ranged from 48° to 74° between April 19th and May 20th, and while usually from 5° to 10° below the air temperature, were on one or two occasions from 2° to 3° above it. This came when after a very warm day came an abnormally cool one, the water, even at the surface, responding slowly to the change. Readings were taken in all cases of the air temperature; of the surface water, the bulb only being submerged; then at six, twelve, twenty-four and thirty-six inches. Additional readings at extreme depths on the bogs varied nothing from the three-foot depth.

Record of Water Temperatures on Cranberry Bogs Observed in April and May, 1905.

Date.	Air temp.	Surface.	Six inches.	One foot.	Two feet.	Three feet.	Four feet.	Five feet.	Over five feet.	Recorder.	Location of bog.	Remarks.
April 19...	56°	48°—52°	48°—52°	48°—52°	48°	....	....	....	....	Dickerson..	Jamesburg ...	Higher temperatures are at upper part of bog; lower at gate.
" 19...	56°	48°	47°	47°	47°	46¾°	46½°	....	....	White	Hanover Sta..	
" 21...	82½°	67°	64°	62½°	59½°	58½°	56°	56°	....	White	Hanover Sta..	
" 24...	66°	61°	60°	60°	59⅓°	59°	57°	....	....	White.........	Hanover Sta..	
" 25...	61°—64°	58°—61°	58°—61°	57°—60°	57°—60°	57°	57°	....	....	Dickerson..	Jamesburg....	Lower bogs at various points.
" 26...	68°	—	65°	60°	60°	60°	....	....	57°	Rider.	Hampton Pl..	Eight feet lowest depth.
May 1...	58°	—	61°	60°	60°	60°	....	....	59½°	Rider	Hampton Pl..	All the observations on this day rate the water as higher than the air and, in fact the temperature reached frost line that night.
" 1...	56°	57°	57°	56½°	57°	57°	57°	57°	....	White.........	Hanover Sta..	
" 1...	53°—58°	59°—62°	59°—62°	59°—61°	60°—61°	60°—61°	....	....	....	Dickerson..	Jamesburg....	
" 2...	60°	—	55½°	55°	54°	58°	58°	....	....	Budd	Pemberton ...	Heavy frost, making ice, at night. 34° at 6 A. M.
" 3...	81°	68°	65°	63½°	62°	62°	60°	57½°	....	White.........	Hanover Sta..	
" 5...	57°	58°	58°	58°	58°	58°	58°	58°	....	White.........	Hanover Sta..	Query. Whether this record is accurate? Too uniform.
" 5...	63°	—	64½°	64½°	62½°	62°	....	....	62°	Budd..........	Pemberton ...	Probably nearer right.
" 6...	66°—68°	63°—64°	59°—62°	56°—62°	61°	62½°	....	....	....	Dickerson..	Jamesburg....	In shade and sunshine.
" 8...	73°	—	69°	68°	65½°	—	....	....	61°	Rider	Hampton Pl..	
" 8...	69½°	69°—72°	68½°—72°	68½°—71°	68½°—69½°	68°—69°	68½°	67½°	....	White	Hanover Sta..	Water being drawn and high temperatures are from reservoir.
" 10...	67°	68°	65°	63°	62½°	62°	62°	62°	....	White.........	Hanover Sta..	Temperature in reservoir.
" 12...	80°	—	64°	68°	61°	60½°	....	....	60½°	Budd....	Pemberton ...	
" 15...	80°	—	67°	61°	62°	....	....	....	....	Rider	Hampton Pl..	Water being drawn and temperatures taken in stream.
" 16...	78°	—	74°	67°	65½°	64°	....	....	64°	Budd....	Pemberton....	
" 20...	64°	—	60½°	60½°	66°	59½°	....	....	59½°	Budd....	Pemberton ...	Reflowing and the water is all of uniform temperature.

OBSERVATIONS ON THE INSECTS.

It would be of little avail to gather statistics like the above without carrying on at the same time a series of observations on the insect to be affected. Opportunity for this was found at the Jamesburg bogs, which have always suffered from the black-heads, and where vines have been allowed to grow on the dams and on some ridges above the water line.

April 19th.—Mr. Dickerson, when making his first temperature records, made, also, a careful search for eggs of *Eudemis,* and found quite a series of them, in good, plump condition, above the water line. Some of these were brought to New Brunswick, where, after two or three days' exposure to the dry air of the laboratory, they collapsed. No trace of larvæ was found at this date.

April 25th.—A second examination was made and more eggs were found—some in the same condition as before, more of them plump and apparently ready to hatch, a few just hatched and boring into the leaf tissue. The place where a larva had hatched and entered was marked by a minute lump of frass or excrement, and when that was removed a little chamber between the upper and under surface of the leaf became obvious, sheltering a caterpillar hardly more than a day or two old. Obviously conditions were favorable for a general hatching, and April 23d was probably the earliest date at which any larvæ appeared. Some specimens were brought to New Brunswick for observation; other sprays containing eggs were tied into a mass and submerged, so as to observe the effect of a water covering at that stage of development. The specimens taken to the laboratory did not remain within the leaf tissue, but began to eat the cells of the lower side, forming characteristic, gnawed surfaces.

May 1st.—The eggs above water had hatched generally, but there was no sign of a leaf-folding anywhere. The casual observer would have concluded that no larvæ were yet present, while practically the entire brood was out. The submerged plants were taken out, examined, and as no change was apparent in the eggs and no larvæ had hatched, they were replaced under four inches of water. It seems certain that either the difference between air and water temperature had checked development or that the physical effect of the covering had produced that result. Additional material was brought to New Brunswick and on May 3d one specimen molted; just ten days after

the first larva was seen, and not over twelve days from the first hatching. At this time the first signs of leaf-folding were noticed. The larvæ abandoned the leaves upon which they had first fed,

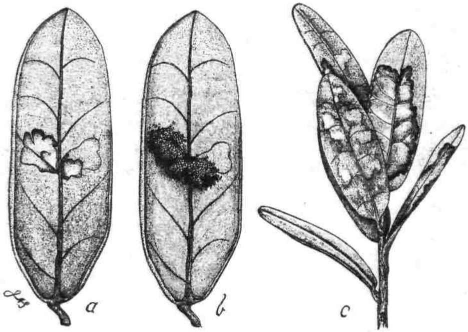


Fig. 20.
Work of young black heads on cranberry leaves: a, the mine in the leaf, free of excrement; b, the mass of excrement on leaf which indicates a young larva; c, feeding done on old leaves before the tips are spun up; all much enlarged. Original.

crawled nearer to the tips of the spray and, where two leaves approached, fastened the under side of the one to the upper side of the other. This was at the end of the first or the beginning of the second stage, hence there was no superficial sign of larval development on a plant until the caterpillars were already more than a week old. Unhatched eggs on the leaves brought in had mostly collapsed, though a few were yet present in good condition.

May 6th.—All the eggs along the bogs had hatched. Most of the larvæ had abandoned their first quarters and had begun to fasten leaves together. There was a general change to the second stage, and any cranberry grower could then realize that the "worms had hatched." The submerged vines were again examined, no larvæ were found, and, as the water on the bogs was to be drawn on the 8th, they were brought to New Brunswick. Examined on the 8th in the laboratory, it was found that most of the eggs were dead; a few were apparently alive, but only one appeared normally developed and ready to hatch.

May 10th.—The water was off the bogs, and it was now possible to examine all those patches that had been over water. In every case well-developed larvæ were found, and in some cases the largest of these were ready to pupate May 12th. On the high ground, along the dams, tips were spun up everywhere, and the yellow head larva of the *Teras* was noted as being present in good quantity. No close examinations were made of the vines on the fully-flowed portions of the bogs.

May 22d.—Most of the larvæ on the upper portions of the bog were in the last stage, ready to pupate, but no pupæ were found. On those parts of the bog that had been winter-flower only an occasional spun tip was found.

May 31st.—Many of the tips had been abandoned by the larvæ, who sought a place to pupate nearer the ground. In a general way it might be said that everything was full grown, in the pupal stage, or ready to come out, and whatever damage was to come from the first brood, had been done.

June 8th.—All the middle and later stages of the *Eudemis* were found, and a large number of adults were flying on the bogs. The first brood had matured, or was about to mature, and very little indeed had come from any of the vines that had been water-covered during the winter. Practically, so far as Jamesburg is concerned, none of the vines that were water-covered up to May 8th produced larvæ of either the *Teras* (yellow-head) or the *Eudemis* (black-head). This is a matter of great importance, as it fixes the dates of development under what may be considered natural conditions.

The date at which an insect hatches from the egg is, normally, a matter of calendar quite as much as of temperature. A low temperature at the date of normal development retards for a very few days; if it lasts a week the young are mostly killed. So if the eggs of *Eudemis* hatch normally on or about April 25th, the larvæ will emerge as near to that date as possible, water-covered or in the open air. In extreme cases new larvæ of the first brood may be found when adults of the summer brood are already fully developed, but that happens only when the conditions are absolutely prohibitive of earlier hatching. The usual result is that when the normal date comes around and the conditions are not favorable the eggs die instead of developing.

No date earlier than April 23d can be reasonably assumed as normal for hatching, and it becomes interesting to determine the conditions just immediately preceding that time.

For Hightstown the temperature varied from a maximum of 82° to a minimum of 24°, all within a space of three days, but the mean maximum was about 63° and the mean minimum was about 36°. On no day was the minimum temperature as high as 60°. Turning now to our bog records at Jamesburg, 60° at a two-foot depth was recorded April 25th and May 1st, and 61° May 6th. At a one-foot depth one degree higher was recorded on the dates given. On the White bog 63° was recorded at one-foot depth, and 62.5° at two-foot depth, May 10th. Very similar temperatures for corresponding dates were recorded by Mr. Budd and Mr. Rider. In other words, the same actual average temperature was reached in the water a very little later than in the air. There was less fluctuation and the warm temperature was continuous, promoting a slow, equal development. On the other hand, the direct influence of the sun and the stimulation of extreme temperatures undoubtedly promoted more rapid growth, as indicated by the fact that the first larvæ were found where the vines themselves were already most advanced. The large number of collapsed eggs found after the water had been drawn indicates that the direct effect of the warm water is such as to destroy the vitality of the ovum, but the fact that I secured sound eggs from below the surface in March, indicates that the water covering only was not at fault. No eggs that had hatched under water were secured this season, but in previous seasons I have found such not infrequently.

CONCLUSIONS.

May 1st, in a normal season, may be safely assumed as the date when all the eggs of the *Eudemis* have hatched on vines that have been uncovered all winter.

A normal season in the cranberry regions of New Jersey is one in which the mean day temperature during April has reached or only slightly exceeded 62°.

Eggs on vines covered by water are in an unnatural position, and, while they maintain their vitality during the winter, they begin to lose it when the water reaches a temperature approaching 60°, especially where the covering is eighteen inches or more.

Vines covered with less than six inches of water are affected by the surface conditions, and eggs will develop or die within a few days after they do on uncovered vines. May 5th may be ordinarily con-

sidered a safe period for that purpose, and water may be safely drawn from such vines May 10th.

Vines uncovered for a week have reached the normal, outdoor conditions, and sound eggs will hatch in due course if development was not started under water—that is, a bog from which the water was drawn April 1st would develop eggs at the same time as on vines that had remained uncovered. A bog drawn April 20th would begin to develop eggs a week later than the normal date, say May 1st, and hatching would not be universal until May 8th.

Two weeks under deep water—eighteen inches or more—at a temperature of 60°, will destroy the vast majority of all the eggs of *Eudemis,* the result being due to some physical influence and not to a favoring of larval development, as I had believed from previous observations.

To determine the period of drawing water from a bog infested by black-heads, where reflowing is not possible, test the water temperature at a two-foot depth, beginning about April 15th. When it reaches 60° allow it to remain for two weeks longer.

PRACTICAL SUGGESTIONS.

The observations made during the latter part of 1904 and the early part of 1905 have led me to believe more firmly than ever in the importance of keeping the immediate bog surroundings, and especially all dams, as free as possible from cranberry vines. There should not be on the bog itself any point that is not completely water-covered; and this will prevent centers of infestation for *Teras,* or yellow-head, start. So far as possible the brush should be cleared up, even into the woodland, and that will do away with hiding and breeding places for species, that resort to the cranberry as an alternate food plant. In general, the cleaner the bog and its surroundings the easier it is to control the pests.

As to the management of the water, so many considerations enter that it is somewhat unsafe to give positive advice. Every grower must know just how much water he has, how much he can do with it and what points he means to gain.

Speaking only from one point of view—that of insect control—when there is water enough to reflow completely I would advise drawing no later than April 1st. That will give the bogs a chance to start slowly

with the season, and the development of the insects will be uniform. By the middle of the month the *Teras* will be at work ovipositing, and by the 25th larvæ of both yellow and black-heads will be gener-

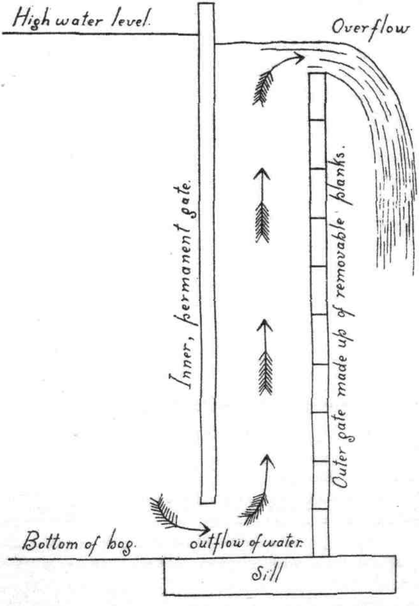


Fig. 21.
Sectional plan of a gate for drawing water from bottom. Original.

ally hatched. Reflow May 1st if the season is normally advanced and larvæ are generally observed. It is a good plan to wait until half-grown larvæ appear, because then one is almost certain that no sound eggs remain unhatched.

If the bogs have water enough to cover completely but not enough to reflow, another method must be adopted. Under no circumstances should the bogs be uncovered until after April 15th if yellow-head injury is to be averted. If the season is late and early April is cold, even that is too early, and April 25th to May 1st is safer. If the black-head (*Eudemis*) is also to be guarded against, dates should be less depended upon, and the temperature of the water gives the safest guide. Two weeks after 59° or 60° is recorded at two feet in a quiet part of the pond, *i. e.*, not in a direct current or near the gates, it will be safe to draw. That will usually bring it to the first week in May, and if an arbitrary date is desired May 10th will be more often right than wrong.

If it be desired to draw earlier and slowly, that can be done by a double gate to take off the water from the lower levels first. The accompanying sketch is self-explanatory, and shows in sections how the water enters at the bottom of an inner solid plant wall into a compartment closed at the bottom and opened at top for the overflow. This outer wall is made up of planking in the usual way, and the scheme leaves the warm upper layers, bringing the vines gradually under the influence of the higher temperature and causing the collapse of any eggs that may yet remain sound at lower depths.

OBSERVATIONS ON REFLOWING.

In the preceding recommendations it is assumed that reflowing the bogs is a certain remedy in all cases, provided the water is kept on the bogs at least twenty-four hours and provided all the larvæ are hatched. In ordinary cases this assumption seems to be warranted. It is certain that I have seen bogs reflowed and completely cleaned where there had been caterpillars in great plenty before. It is also certain, from direct experiment, that pupæ are nearly as much affected by the water covering as the larvæ, and this was proved by a simple laboratory experiment.

July 19th, pupæ of the *Eudemis* were submerged in vials filled with water. No. 1 contained two pupæ, which were left covered forty-six hours, and were then transferred to a dry vial carefully kept from jars. Nos. 2 and 3 contained two pupæ each, which were left covered sixty-five hours and then dealt with as before. The five remaining pupæ

were kept submerged for ninety hours before they were placed in dry quarters. In no case did any pupæ develop.

Based upon previous experience and observations, when, early in May, I found all the *Eudemis* eggs hatched, I wrote Messrs. White, Budd and Rider, suggesting that the time to reflow had arrived; a conclusion which had been in part anticipated in one case at least. But the results were not at all as complete as was expected. Great quantities of young larvæ were destroyed and were found floating on the surface, but in every instance there was a large surplus remaining that made itself appreciably felt in early July, when the second brood was at its best, or worst. In one case the trouble was admittedly due to uncovered vines in great part; in at least one other that factor was altogether excluded, and, on examining the records made by Mr. Dickerson, the probable explanation is that the survivors were those half or two-third grown examples that were lodged between two closely spun-up leaves. All the very recently hatched insects were reached, and all those that were full grown or in the pupal stage probably succumbed to the covering, but those that remained quiet in their shelter, especially in the deeper parts of the bogs, escaped. The probability is increased by the observation that spun-up tips kept submerged for four days rose readily to the surface after their weight which kept it down was removed. The reflowing then, during the early days of May, was too late to reach the half-growth forms and too early to catch any of them in the pupal stage when they are not so well protected. Covering not later than May 1st would have been more effective, because, while all the eggs had hatched, there would have been fewer in the protected stage. On the other hand, allowing the insects to develop until pupation was general would have left very few in the protected stage. That period was about May 30th, and reflowing at that time would be likely to be more effective than the earlier period.

On the whole, the question is now whether, after all, late holding is not the easiest as well as the most effective way to use the water as against the two species of vine worms.

THE CRANBERRY FRUIT-WORM.

Mineola vaccinii Riley.

This insect, ordinarily much more plentiful in Massachusetts than in New Jersey, was unusually abundant on our bogs this year, and a brief review of our present knowledge of the best methods of dealing with it would seem to be in place.

During the two years last past a series of systematic observations and experiments have been made by Mr. Henry J. Thayer, of Boston, Mass., and the results of these he has been kind enough to communicate to me. It appears now that the life period of some of the stages is very much longer than had been believed and the development is much more irregular. It appears, also, that while insecticides are entirely useless to lessen injury, a proper handling of the water is very effective, and Mr. Thayer has reduced the injury done on his bogs to a very small percentage.

The adult moths appear on the bogs, in ordinary seasons, early in July, when the fruit is just beginning to set, but isolated examples are on the wing much earlier, Mr. Thayer's breeding records showing the first example June 16th. They remain on the bogs throughout July and probably most of August, some hibernating larvæ yet remaining unchanged to pupæ in the early days of that month. The heavy flight, however, is probably over soon after the middle of July, when young larvæ are already quite plentiful. That the development is very uneven is shown by the fact that in early September caterpillars are sometimes found in all stages of growth, but this, again, varied with the season, for practically none was found in the berries September 23d, when I visited Mr. Thayer's bogs.

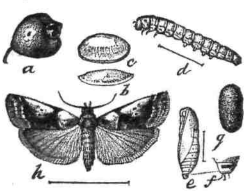


Fig. 22.
Cranberry Fruit-worm: *a*, berry showing egg; *b*, *c*, egg; *d*, caterpillar; *e f*, pupa; *g*, cocoon; *h*, moth: all save *a* and *g* enlarged. After Riley.

The moth, with wings expanded, measures about three-fourths of an inch, and is of a glistening ash-gray, mottled with white and blackish; the fore-wings narrower and rolled up, so as to cover the hind-wings

when at rest. It usually sits on the stem during the day, head down, and does not fly readily. When disturbed it flies with a darting motion for quite long distances, so it is not often seen and recognized by the ordinary grower. Of dozens of insects sent in as fruit-worm moths, it is rare to find even a single example of the true species, and that usually in such condition as to be unrecognizable.

The eggs are pale yellowish in color, nearly round in outline, almost flat, and so soft that they adapt themselves readily to any inequalities of the surface upon which they are laid. Usually they are laid upon the young berry, preferably at or near the calyx end, but they may be found anywhere on its surface, and probably, also, on the leaves. The worms emerge in about five days, and for a day or two feed on the outside of the fruit. Then the little fellows bore into the berry itself, and each one closes the tiny opening by a dense web of silk, so skillfully made that it is difficult to find the point of entrance. The seed capsule is at once attacked, eaten out and then the larva seeks new quarters. The abandoned berry soon after turns red, shrivels and dies. Several fruits may be eaten out by a single caterpillar, and until it is half grown or more the insect always closes up the opening it makes very carefully. When nearly full grown it becomes careless of this and leaves a jagged opening, through which frass or excrement is often extruded—opening the way, thereby, to the parasites to which it is subject. Sometimes it even fastens together several adjacent berries, eating from one into the other and ruining all. By the time the fruit is half grown on a badly-infested bog it will begin to turn red, and to the ordinary observer will appear to be ripening. But the grower knows better and realizes that it is all lost to him, a harvest of dried shells only being left at picking time.

Full growth comes, ordinarily, in late August or early September, some worms being already out of the berries August 25th, but more of them leaving every day after September 1st. At picking time all the moths have disappeared; many, perhaps most, of the worms have left the berries and worked below the surface; but many are not yet full grown and a few still are so small as to have the silken covering over the point of entrance.

Mr. Thayer records collecting two quarts of worm-infested "Howes" August 27th, and that several larvæ left the berries and entered the sand less than an hour thereafter. September 4th, eighty-five cocoons were found and more wormy berries were added. September 11th

there were 141 cocoons, and September 16th there were yet all stages down to small larvæ in silk-closed berries.

The full-grown larvæ are rather more than half an inch in length, of a bright green color, with a variably-marked, reddish tinge on the back. The head is a little narrower than the first body segment and is yellowish, except for the brown mouth parts. The body segments are transversely wrinkled and clothed with a few sparse, rather long hairs.

These caterpillars winter in silken cocoons, which they make by first rolling in the sand, gluing the surrounding particles together with saliva, and then spinning their web inside the rough casing thus formed. The moist sand of the surface of a cranberry bog is just such a surrounding as the insect needs. If the bog remains unflooded during the winter the great majority of all the larvæ will survive to complete their transformations. If the bog is covered with water a considerable percentage will be killed off, this percentage increasing in proportion to the earliness of the flooding.

Mr. Thayer's notes show that of the cocoons collected and submerged soon after they were formed, practically none survived, and that late submergence and early withdrawal in all cases favored the insects.

Pupation does not take place within the cocoon until shortly before the moths are due to emerge. May 23d is the first date at which pupæ were actually noted in confinement, and June 17th is the earliest for actual bog conditions. As to the latest change, that did not occur until August, when some of the new larvae were already almost full grown. There is no actual record of a lap-over, but by the time the last moth is on the wing the first-born caterpillars are already full grown, if not actually in cocoon.

Remedial Measures.

These have been indicated in the discussion of the life cycle and in the references to Mr. Thayer's results. Flow as soon after picking as is convenient and safe, and keep on the water, either altogether or for two or three weeks, if improvement or other work is necessary on the bogs. But in no case flow permanently before the middle of October *unless the foliage has ripened and turned.* This process is advantageous also as against the girdle-worm where that occurs, so that a

double point will be gained. The date of drawing the water in spring is less important, but late holding is better than early drawing.

Where wormy berries are picked and get into the storehouse the larvæ will emerge when they are fully developed and will find some crevice or shelter in which they will spin up and attempt to complete their development. It will be the part of wisdom to furnish plenty of shelter for them in the way of loosely-piled slats or boards, which can be burned during the winter. Boxes and trays can be examined and cleaned of cocoons, and the cranberry-house itself should be thoroughly cleaned out. But even if nothing is done, few of the larvæ tempted to spin up indoors come to maturity. They need moisture in spring when ready to pupate and die when kept dry.

Mr. Thayer records that cocoons were found in late fall in great numbers in spaces between floor boards, but that the field mice cleaned them nearly all out before the next following spring.

THE ONION MAGGOT.

Pegomyia cepetorum Meade.

This is really only one of several species that feed in the onion bulb, and is an imported or introduced form, but in New Jersey the other kinds are not common, and one, at least, seems to follow injury caused by some other agency rather than act as first cause.

Hibernation is in the adult or fly stage, in barns or among rubbish and other shelter, largely in the places where onions are stored, and activity begins in spring as soon as the weather becomes settled. This hibernating adult somewhat resembles the ordinary house fly in appearance, and may be mistaken for it, but it is much paler, gray or yellowish in color, with prominent, black bristles, and in shape it is rather narrower, more elongate and more cylindrical.

These flies are in the field as soon as the young onions begin to develop, and lay their elongate, whitish, almost spindle-shaped eggs in little masses at the base of the plant; if possible, a little below the surface if there is an opening. There is no horny, egg-laying tube, so the insect cannot pierce the growing tissue, nor can it force its eggs into the soil; but there is a short, extensile and flexible ovipositor, by means of which it takes advantage of any opening or crevice that may exist around the stalk.

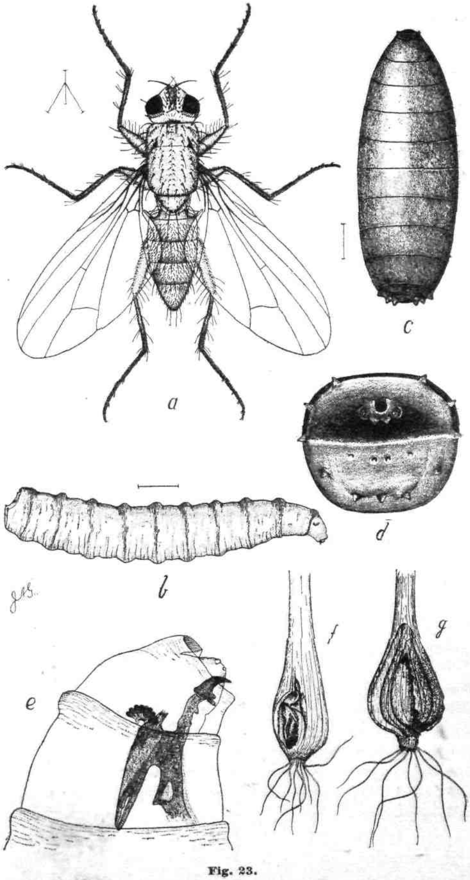


Fig. 23.

The Onion Maggot, *Pegomyia cepetorum* Meade: *a*, the adult fly; *b*, the maggot; *c*, pupa; *d*, anal end of maggot, with breathing holes; *e*, head, showing mouth parts—all very much enlarged; *f*, young onion plant showing injury by maggots; *g*, section of bulb further advanced, showing the extent of the injury. Original.

The eggs hatch very soon after being laid, and the young appear as small, footless maggots, tapering toward the mouth end and squarely cut off or truncate behind. They attack the young onion, bore into the tissue, and decay begins around them almost at once. The young plant is very sensitive to this kind of injury and the leaves wilt and droop.

If we examine the half-grown maggot more closely we will note that it has no distinct head, no feet and no other obvious organs of locomotion; but it is ringed or wrinkled and moves along by extending its body forward, holding its position by the anterior wrinkles and drawing the hinder part of the body forward.

The posterior, or cut-off, portion of the body is set with little hillocks or conic tubercles, and there are two well-protected spiracles or breathing holes.

The pointed or head-end is furnished with a small mouth opening, with a pair of fleshy lips or jaws and two pointed, curved, hook-like, corneous structures. By means of these sharp-pointed jaws the larva scrapes and punctures the surface of the onion, and by means of the fleshy, lip-like structures it gets the exuding plant juices into the mouth and so on through the gullet into the stomach. The dark framework seen within the enlarged anterior rings of the larva in Figure 23, shows the chitinous support for the muscles that work the sucking or pumping structures of the gullet. Without biting mouth structures, then; the insect is nevertheless able to get into a young onion, and, once in, progress is even more rapid, because of the aid given by the organisms favoring decay. Rarely there is a single maggot in a small bulb; more commonly there are half a dozen or more. The first brood comes to maturity about the middle of June, and perhaps the most serious part of the early injury has been done at that time. When the larva is full grown it begins to contract, becomes shorter, more regularly oval and cylindrical and changes to a dull brown color. In this—the pupal—stage it is inactive and is really only a cover to the real pupa which develops within the dried larval skin. In this condition it remains for a few days only before changing to the adult or fly stage already described.

It is said that there are three broods during the season, and that is indicated by the dates at which larvæ have been found, but the later broods are not so numerous in specimens as the earlier, or at least seem to do much less mischief.

Injury Caused.

There is no stage in the growth of the onion, from the seedling to the seed-bearing bulb, that is not subject to attack, but it is the small onions, from one-half to one inch in diameter, that seem to suffer worst. At that stage of their development the amount of tissue is not great; the injury caused by several boring maggots becomes quickly felt, and disease enters at once. A large onion may stand considerable local injury without showing it very much, and may even outgrow a slight attack if there is plenty of stimulating plant food. When decay begins in an onion, be it ever so slight, it is apt to give entrance to a colony of white mites small, spider-like creatures; which live just at the edge of the decayed portion and work ever further forward into the sounder tissue. Naturally, such a bulb develops little and the plant above ground turns yellow, droops and dies.

When the maggots are very numerous and the onions small they may and do go from one bulb to another, and in leaving one bulb the company does not remain together, but may divide into several parties, each taking a different victim.

The indications of an attack are seen in the wilting and drooping plants in a row, and as soon as this is noticed active measures are in order.

Remedial Measures.

These are of two kinds—preventive and destructive. Preventive measures are those which aim to keep off the flies so that they will not lay eggs, because either the odor of the used material is offensive or it is really harmful to the insects.

Kerosene and sand, at the rate of a pint of kerosene to ten quarts of dry sand, thoroughly mixed, is spread around the plant or along the row, and exercises a deterrent effect, if it does not also kill young larvæ that may be hatched from eggs already on the plants. This should really be put on before the flies have begun to oviposit.

Tobacco.—Finely-ground tobacco, or tobacco dust, may be liberally applied along the rows without danger to the plants, but rather to their advantage, because it is a good fertilizer. It should be finely ground, for, as a dust, it is a better repellant, and also more likely to kill any young larvæ that may come into contact with it. When it rains the tobacco extract will be more abundant, will go down deeper into the

ground and will be more quickly fatal to young maggots and stimulating to the plants. I prefer the tobacco to the kerosene and sand because of the double value.

A good preventive measure is to avoid the use of manures and decaying vegetable material generally, so far as possible. Maggots are essentially feeders and inhabitants of vegetable decay, and moist, soft soil attracts them. The advice is, therefore, depend upon mineral fertilizers so far as possible and so far as the crop will be favored.

In the way of destructive measures, fertilizers also have a place on the light soils of Southern New Jersey. As soon as infestation is noted, turn a shallow furrow from the row, as close to it as is safe. Apply a liberal dressing of nitrate of soda, with kainit or muriate of potash, and turn back the soil. Use nitrate at the rate of 300 pounds per acre and kainit or muriate at about the same rate. The application acts best made just before a rain, and is, of course, a stimulant as well as a remedy.

On heavy land this application does not work as well, but its effect as a stimulant is useful, and, in any event, the growing onions should always have an abundance of available plant food.

Another method of prevention is to avoid all accumulation of rubbish, or to allow the accumulation in fall, with the object of burning during the winter, to destroy hibernating insects. So the sheds and barns where baskets, trays and other paraphernalia necessary to the handling of the crop are stored should be thoroughly cleaned, and, if possible, fumigated with sulphur during the winter. Baskets, trays and the like can be put into a tolerably tight building and thoroughly cleaned of all hibernating forms. Open sheds are more difficult to deal with, and for these a thin whitewash, to which carbolic acid has been added, may be used by spraying the material with as much force as possible into all cracks and crevices in which the flies may find shelter.

About the only insecticide that seems to have been at all effective is the carbolic acid emulsion, prepared as follows: Dissolve one pound of soap, shaved fine, in one gallon of boiling water; add one pint of crude carbolic acid and make into an emulsion with a force pump; dilute with thirty parts of water and apply liberally to infested plants. A modification of this formula, given by Mr. Chittenden, doubles the amount of carbolic acid and suggests a dilution with from thirty-five to fifty parts of water. Here, also, it is important that the appli-

cation be made at as early a period as possible after the work of the maggots is noticed, for the smaller the insects the less they have bored into the plant and the more easily are they reached and killed.

It is also a good plan, wherever a wilting plant is noticed, to take it out with a trowel, so as to be sure to get all the maggots around it, and put plant, maggots and all into a pail. When all infested plants are collected in this way, drench with kerosene and bury at least six inches deep, firming the ground so that in case a pupa escapes the oil the developing fly will be unable to work its way out.

Finally, onions should not be grown on the same ground two years in succession if it can be avoided, and the new field should be as far removed as possible from the old one.

Growing onions under these conditions means work and constant observation, but while neglect is apt to result in ever-increasing injury, constant care and attention will result in an ever-decreasing percentage of loss.

THE CORNSTALK BORER.

Hydroecia nebris Gn.

Each year there is some complaint of a borer in corn and tomatoes; occasionally, also, in potatoes, and sometimes, as in the season just past, considerable injury is done. The borer, when first noticed in middle or late June, is a slender caterpillar about an inch in length, with the two ends of the body unlike in markings. There is a dark band on the back that extends from one end to the other, but on the sides the stripes extend only to the middle of the body, where there is a dark belt.

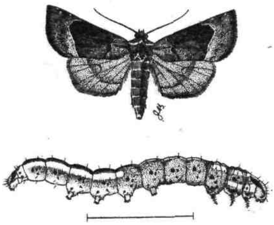


Fig. 24.
Cornstalk borer, *Hydroecia nebris* Gn.: moth above; half grown larva below—the latter enlarged. Original.

It is at that season and in that stage that it attracts most attention, and when most of its notable injury is done. Later in the season, say about the end of August, when the borer is full grown, it is altogether different in appearance. It is then

over one and one-half inches in length, quite a stout, though by no means a chunky caterpillar, livid, whitish brown, without stripes, with some blackish tubercles, bearing tufts of short bristles, the head and anterior feet black. In that stage, if in corn or tomatoes at all, it is far down in the stalk, and any infested plants then found have either outgrown the injury, as in corn, or have little or no crop, as is usual in tomatoes.

It is rare that the borer is found in large fields of either corn or tomatoes, and it is usually the garden or the small field that suffers most. Nearly or quite thirty years ago, when Dr. C. V. Riley wrote of this species in the Missouri reports, its injuries were of the same character and of the same irregular occurrence. The life history, as then written, has been copied ever since, with little variation and no question even in very recent bulletins.

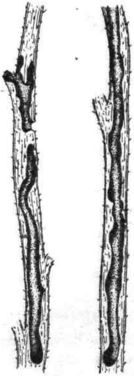


Fig. 25.
Work of the stalk borer in tomato vines. Original.

When the caterpillar reaches its full growth, in August, it changes to a dark, chestnut-brown pupa, either in the infested plant, near the surface of the ground, or in the soil close to it. The moths begin to appear about the 10th of September, and are modest, mouse-gray in color, with lighter powderings, and a pale, transverse shading across the outer part of the wing—much better marked in some specimens than in others. The figure (24) shows the general appearance and average size fairly well, while the caterpillar, not much more than half grown, is somewhat enlarged. Dr. Riley believed that the moth lived through the winter and laid its eggs in the spring, as many of these Noctuid moths do, and so he stated without having actually seen the eggs. This statement was accepted as a fact and has since been repeated as such, instead of a mere probability.

When seeking for a means of checking the injury caused I was led to question the accepted period of egg-laying, and wrote to all my entomological friends of whom I believed that they might be able to give definite information, but no one had actually seen the insect deposit its eggs and no definite information was available. At my

request a number of these correspondents collected larvæ, and in the laboratory some 200 were gathered together by Messrs. Brehme and Grossbeck. Mr. Henry Bird, of Rye, N. Y., who has made rather a specialty of the moths belonging to this group, was good enough to place at my disposal his notes and observations, and Mr. William Beutenmuller, of the American Museum of Natural History, bred out and observed a lot of the specimens, and was the first to actually note the egg-laying period. From the information thus gathered, supplemented by personal observation and laboratory experiments, the following life history is made out.

Life History.

The moths make their appearance in early September and lay their eggs, preferably on the stalks of ragweed, but also on dock, pigweed or almost any other thick-stalked weed that they can find. It is probable that, in the absence of other plants, corn, tomato or potato stalks would be used. The eggs are compared by Mr. Beutenmuller to a minature muskmelon, flattened above and below, with the sides grooved. An individual female may deposit 400 or more of them, this number being determined by counting the eggs in the body of some of the females that were bred in the office.

The eggs remain on the plants during the winter, and by far the greater number perish before the advent of spring. Such as do survive hatch during the last days of May and early days of June, and the little caterpillar bores into the stem of the first suitable plant that it can find—ragweed preferred. A great many of these small plants die as the result of the attack, and the larva is compelled to change its quarters. It is even likely that other reasons may induce a change, and toward the end of June they appear in the cultivated plants. Growth is not rapid, and it requires the whole time between the beginning of June and the end of August—a period of nearly or quite three months—to mature the caterpillar. The most rapid feeding seems to occur in late June and early July, when the effect upon the plants becomes most noticeable.

In August, sometimes a patch of the giant ragweed will have every stalk infested, and burdock is only less susceptible to attack. Infested plants are readily recognized by an irregular, blackened hole in the stem, near the base, through which the excrement is forced. From the

number of such larvæ sometimes found it seems surprising that the insect is no more widespread than it is, and Mr. Bird explains it thus:

"Happily, nature has the matter pretty well in hand. With no other species [of *Hydroecia*] does parasitism exist so severely as it does with *nitela* [another name for this insect]. Two hymenopterous and two dipterous parasites play the very mischief with the species, and while others also suffer, it falls to *nitela* to bear the brunt. It seems enough for the female *Hymenopter* to merely find a burrow and thrust therein an ovum—the young maggot appears to be equal to keeping up his end of the contract. It seems able to live for some time in the moisture and frass of the burrow and trust to a chance contact with the host. The small *Dipter*, however, I believe, enters the burrow and places her eggs on the larva to the number of twenty or more. I have yet to get the name of this fly, but we know the larva's name from this time on is *Dennis*."

The pupa also seems subject to numerous perils, and, on the whole, only a small proportion of the insects reaches the adult stage. As adults they are occasionally attracted to light, but are hardly ranked as common in collections anywhere.

Remedial Measures.

No satisfactory method of reaching borers in herbaceous plants has yet been proposed, and it is usually best, when an infested plant is found, to take it out and destroy it, borer and all. But in this instance it appears that the cultivated plants are not the normal food of the insect, and that attacks are exceptional rather than the rule. It appears, also, that the real food plants are some of the common, large weeds, without which the borers would not occur at all.

The suggestion is obvious—keep down all such weeds in and around your fields and gardens, and in no event allow them to overrun the ground late in the season. A weedy field in September is an invitation to the moths to lay eggs, and there is always a chance that in preparing the ground for next year's crop some of these eggs may survive. Abolish the ragweed, burdock, pigweed and the like, and no further trouble need be apprehended. The danger period is September, when eggs are being laid and dirty fences and roadsides offer points of survival from which there may be an invasion of the neighboring fields during the June following.

THE PEACH SOFT SCALE.

Lecanium persicæ Modeer.

This is a well-known European species, whose general life history was written there one hundred and sixty years ago, and in the United States, in some detail, by Howard, in 1894. At that time the insect was already present in ten States or territories and the District of

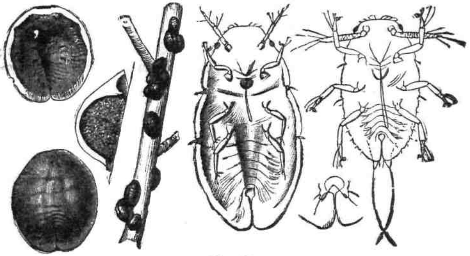


Fig. 26.
The Peach Soft Scale, *Lecanium persicæ* Mod.: newly-hatched larva at right; unimpregnated female next; twig with full-grown females; at left are females from above and below and cut longitudinally; all save twigs are enlarged. From Howard, Div. Ent., U. S. Dept. Agric.

Columbia, ranging from New York to New Mexico. Only a few localities were known in each State except Maryland, and New Jersey was not mentioned in the list of affected States. How the insect was originally introduced into the United States is not known, but no complaints of serious or widespread injury seem to have been recorded. It is confined to peach in our experience, and when very abundant has been known to cause the death of young trees. On older trees it clusters during the winter upon the twigs and young shoots so as to completely cover the surface in the worst cases.

Life History and Habits.

The insect appears to over-winter mainly in the advanced female condition, in which stage it is a hemispherical, slightly elongated, mottled brown object, rather more than an eighth of an inch in average

diameter. Eggs begin to form in May and to hatch in June, according to published accounts, though all the early stages can be found at almost all times during the summer. The young are yellowish in color, almost transparent in appearance, and set on the under sides of the leaves, along the veins, in great numbers. Only a few examples were found set on the twigs in August. The insects excrete honey dew in considerable quantity, and wherever it falls a black soot fungus develops upon it. This has a tendency to choke the leaves and cause them to drop, and when it appears on the fruit makes the latter unsalable. The male is a very minute, two-winged fly, orange red in color, and resembles in a general way the same sex in other species. The impregnated females that have set on the leaves migrate to the twigs in late summer and grow rapidly to the winter condition.

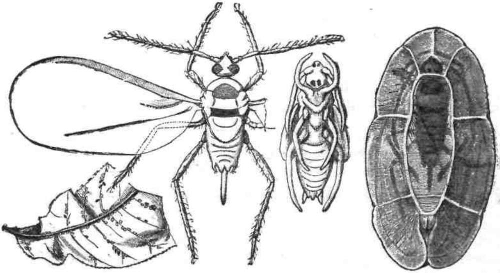


Fig. 27.

The Peach Soft Scale, *Lecanium persicæ* Mod.: male scale at right; pupa next; adult male next; leaf with young male scales at left—last natural size, all others greatly enlarged. From Howard, Div. Ent., U. S. Dept. Agric.

At the end of the first half of August the infested trees near Bridgeton had still a considerable number of over-wintered females, which were yet bearing young. A very few eggs were found, but under most of them was a little mass of newly-hatched larvæ. In fact, so general was this condition that it was at first believed that the young were born alive, no traces of the eggs being apparent. Only on close search were a few examples found in which there were some unhatched eggs in the mass. Moving larvæ were few in number, but recent sets on the leaves were abundant. Well-advanced females were distin-

guished by their broader, more oval form; but the majority seemed to be males in the pupal stage, or just about ready to emerge. Every stage in the entire life cycle was therefore present at the same time. September 28th all the females had left the leaves and no young were observed. Infested trees were easily recognizable by the sooty appearance and the foliage was mature and ready to drop.

Remedial Measures.

A great deal can be done to lessen the numbers of this insect by judicious trimming in the winter. The insect does not get readily from tree to tree, and once clean, a plant is not quickly reinfested. Very badly-affected trees should have all the worst twigs and branches cut out, and on young trees it will pay to cut back vigorously, even at the expense of a crop. The tendency of the scales to set toward the tips of the twigs makes this trimming more practicable.

Summer applications on scales have not proved satisfactory, and on peach are likely to be less so than on other fruits, because the foliage is more susceptible to injury. Besides, the long period during which young develop would make it necessary to make several sprayings to reach all those that are born.

The lime, salt and sulphur wash applied in late fall will probably be as effective as anything that can be used, and will serve to clean the soot fungus from the trees, enabling them to start the season following with fresh energy.

The recommendation is, therefore, to spray all infested trees late in October or early in November with a lime and sulphur wash, preferably the boiled mixture, with some salt. After midwinter go through the trees carefully and cut out all badly-infested wood and all such as appears to have escaped the spray. If, in spring, there is still a notable remnant of apparently living scale, duplicate the application just before the trees make a start.

Instead of the lime and sulphur, the soluble petroleum may be used and will probably be quite as effective against the scales. It will not be so useful as a tree cleaner, however, and will not so completely remove the remnants of the soot fungus. In those orchards where only a few trees are infested or where the infestation is slight, all the scaly wood should be cut out.

THE COTTONY MAPLE SCALE.

Pulvinaria innumerabilis Rathv.

General Observations.*

This insect derives its name from the cottony covering that it secretes for its eggs, which are deposited beneath the posterior portion of the body. While it has been found infesting grape, Virginia creeper (*Ampelopsis quinquefolia*) and other plants to some extent, it occurs most commonly on the soft or silver maple (*Acer saccharinum*), and in New Jersey is found almost exclusively on that species. As with many other injurious insects it occurs more plentifully some years than others, and sometimes becomes a real pest. This was the case in 1904, when it was unusually abundant at Montclair, Newark and several other points, and seemed likely to be as plentiful in 1905. Although the insect has been briefly treated in several of the reports and bulletins, this occurrence offered a good opportunity for a careful study of its habits and life history, as well as its natural checks. Accordingly, in February, 1905, infested localities were visited and the condition of the trees and insects was noted, while throughout the spring and summer twigs were collected and received from several points, though principally from Montclair, through the kindness of Mr. Malcolm H. Smith and Mr. W. D. Kearfott.

February 2d, infested twigs were collected in Newark to determine the condition of the hibernating insects, which were mostly scattered along the under side, with now and then a few on the upper surface. They usually lay parallel with the twigs, extending from near the tip back on to the older growth. In some places somewhat torn, cottony masses, the remains of the previous year, were observed, and under the edges of several of these a few very small, parasitic larvæ and pupæ, in rather hard cocoons, were found. In all some sixteen twigs were examined, averaging about a foot in length, with some sixty insects on each, one-third of which were alive and two-thirds apparently dead. These hibernating insects were small and dark brown in color, about one-sixteenth of an inch in length and about half as broad. They were oval in outline, a little convex, with a slight ridging along the center. A few smaller, darker and more

* This narrative is by Mr. E. L. Dickerson, who made the direct observations under my direction.

convex forms, each with a small hole in the upper surface, were also noted, and were scales of the previous season from which parasites had emerged.

February 17th, more infested twigs from Newark were examined, with practically the same result, except that these were more thickly

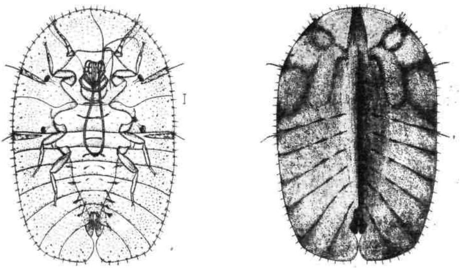


Fig. 28.

A wintering scale, taken February 1st. Seen from below to the left—from above on the right; much enlarged. Original.

infested. Twigs received from Montclair, March 1st and 15th, showed considerable difference in the amount of infestation, some bearing a large number of insects, others very few, while on some twigs torn, cottony masses or a small number of old parasited scales were apparent.

During the latter part of March and early April parasites emerged in the laboratory from cocoons found February 2d, and these were determined by Dr. William H. Ashmead as *Eunotus lividus* Ashm.—a small, dark blue, parasitic wasp, measuring about one-sixteenth of an inch in length.

April 11th, some seventy-five infested twigs were received from Montclair, collected at three points, where the infestation had been bad the previous year, but in general their condition was the same. Several of the twigs had no scales, others only a few, while upon some there were a number of insects. About two-thirds of the scales were apparently alive and slightly larger than those examined earlier in the season. In a few places there were remains of old cottony masses, with some old parasitic cocoons and a few good ones, and a number of old parasitized scales were also noted. At this time the insects

were attached by their beaks, and in some cases so strongly that the mouth parts were pulled out in removing them from the twig. This was not the case earlier in the season, when the insects seemed more loosely fixed. That a much larger proportion of individuals appeared alive on these twigs is due to the fact that many of the dead ones had fallen off or had been removed in some other way. April 18th, more twigs were received from Montclair, with the insects in a similar condition.

Several times during the latter part of April infested twigs from Montclair and Newark were examined and showed the scales to be developing somewhat irregularly, about one-third being alive and ready to move when disturbed. On twigs received April 29th, two distinct forms were found. The one similar in appearance to the hibernating form, but distinctly larger; the other, of the same size as the winter form, more convex and shining. This was, in fact, a parasitized form like the old ones found early in the season, although at this date neither larva nor pupa was readily discernible within the parasitized scale.

May 9th, more infested twigs were examined and a distinct increase in size was noted, as well as the fact that the insects were fixed more

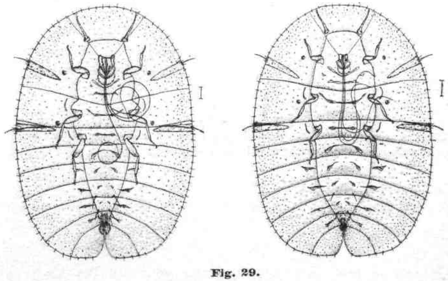


Fig. 29.

Scales increasing in size; to the left taken April 23d, to the right taken May 1st; the legs are of the same actual size as in Figure 28, and will serve to show their proportion to the developing female; much enlarged. Original.

closely to the twigs. The parasitized scales were more apparent, and, on the whole, there were nearly twice as many of these as there were healthy examples. The parasitic larvæ were now easily recognized

within the parasitized insects. Conditions continued the same for the next few days, except that the scales developed rather rapidly and irregularly. By May 15th many of the insects measured three-sixteenths of an inch in length, while the smallest were only about half as large. The character and condition of the scales also varied considerably. In many cases the healthy and parasitized scales were about equal in number, while on other twigs there were only a number of partly developed, dead insects, and occasionally some old parasitized forms. Sometimes the live scales were grouped, while in other cases they were set pretty evenly along the lower side. Some of the parasitized forms were placed in a bottle to develop.

May 17th, a few twigs were received from Montclair and the insects on them carefully examined and counted. There were 180 live, de-

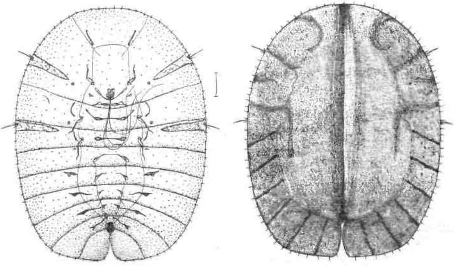


Fig. 30.

Full-grown female scale ready to reproduce; underside on the left; upper surface on right; legs same actual size as in Figure 28; much enlarged. Original.

veloping scales, 440 parasitized scales and several undeveloped and half-grown dead forms, or by actual count two and one-half times as many parasitized as healthy insects. As compared to the conditions in February, the twigs examined at this time averaged eight inches in length and showed eleven good scales and twenty-nine that were parasitized.

May 18th, seventeen parasites emerged from the scales in the bottle, and these were determined by Dr. Ashmead as *Coccophagus lecanii* Fitch., a very small, black *Hymenopterous* insect, with a yellow spot between the base of the wings. May 23d, when more twigs were examined, 108 developing scales, 252 parasitized forms and a few dead or

Fig. 31.

A twig badly infested by the Cottony Maple Scale; about natural size. Original.

undeveloped insects were counted. On this and several successive days numerous parasites emerged in the laboratory from the collected material, but it was not until the 26th that I found them outdoors.

About this time a new phase in development occurred. On twigs collected at Newark it was noted that some of the insects were beginning to secrete from points on the under surface a cottony material, and apparently the increase in size had ceased. This cottony material was excreted from narrow areas near the base of the anterior and hind legs, extending in a line to the margin and from a spot near the anus, making five in all. These places had been noticed in the hibernating insects before any secretions occurred, but a few days later (June 2d), when the insects showed the cottony secretion in greater amounts, it was noted that it was also exuded in single fibers, from minute openings situated in a rather broad group along the margin, extending somewhat parallel with and back from it, and especially abundant around the anal area.

On this date, too, eggs were observed under some of the insects. Several scales, each with a small hole in the upper surface, near the end, through which a parasite had emerged, were also noted, and a few of the parasites were observed on the twigs. The developed scales at this period were somewhat variable in size, but averaged about a quarter of an inch in length and were broadly oval in outline. Owing to the fact that they were filled with eggs they were rather plump and convex.

Development was proceeding at about the same rate in all the infested localities, although somewhat irregularly. Twigs from Montclair, June 5th, showed eggs within the cottony masses, and they were similar to those observed at Newark, but some insects had not yet begun to even show the cottony secretions. By this time most of the parasites had emerged, but a few in the Montclair material had not, and upon opening infested scales I found fully-developed adults ready to emerge and one still in the pupal stage.

With the increase in the number of eggs deposited, the cottony material also increased and became more prominent than the insect itself, the posterior part of which was lifted by eggs and cottony material until it formed almost an angle of forty-five degrees with that part of the body which remained against the twig. The insects were found in this condition at Montclair, as early as June 15th.

The examination at. this time also showed that numbers of a *Coccinellid* larva were upon the twigs, attacking the *Pulvinaria* egg

masses and eating the eggs. A few egg masses that appeared normal were torn open, and in several I found a *Coccinellid* larva—in one case two—and the eggs partly destroyed. These larvæ are white in color and the upper surface of the body is covered with a material resembling that secreted by the *Pulvinaria*. It seemed probable that these were the larvæ of *Hyperaspis signata* Oliv., as we had found this beetle associated with the *Pulvinaria*, and subsequent breeding proved this to be the case. An example of the *Coccophagus* was also observed on the twigs, but although I watched it for some time I could not observe any effort to deposit eggs.

June 20th, another trip was made to Montclair in company with Mr. Malcolm H. Smith. There were several badly-infested spots in the town, and the infestation in each case gradually lessened away from the infested centers. Many of the egg masses were found infested by the *Coccinellid*, and in some instances the larva within the cottony mass would cause it to become enlarged. These larvæ varied considerably in size and seemed to be in all stages, from very small to those large enough to pupate. Twigs with the *Coccinellid* and *Pulvinaria* were placed in a battery jar to bring the *Coccinellid* to maturity and also to obtain larvæ of the scale. June 20th, a few scale larvæ were observed in the laboratory, on twigs collected some days before, and on June 25th they were observed on an infested tree in Newark. In that city the infestation was not as great as in Montclair, and neither were there as many *Coccinellid* larvæ in evidence, although a few in about the same condition as at Montclair were observed.

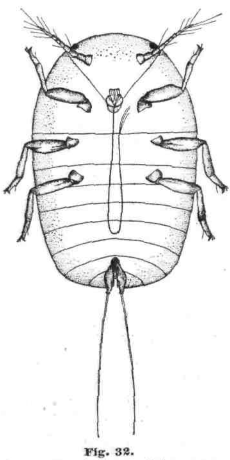


Fig. 32.
Larva just hatched; actual size a mere point. Original.

To determine how the number of live scales at this time compared with the number observed in the hibernating stage, the insects on several twigs were carefully counted, with the result of an average of

thirty-seven fully-developed live scales with egg masses to a twig ten inches long. These twigs were badly infested and the egg masses were ranged closely, one behind the other, but there were many like this on badly-infested trees.

June 24th, infested twigs were received from Keyport and showed scales from which parasites had emerged as well as some *Coccinellid* larvæ. On this date the first pupæ of the *Coccinellid* were found in the laboratory, but an examination made at Montclair did not show any pupæ, although a few larvæ were crawling on the tree trunks and getting into crevices, apparently ready to pupate. Examinations made at Newark two days later showed a few *Coccinellid* larvæ and one pupa within the cottony mass of *Pulvinaria.*

June 28th, examining the infested trees at Montclair, it was found that the egg masses had been pretty well torn apart, and not one could be found which was not infested by *Coccinellid* larvæ, or had not been eaten out by them. In one spot I found eight larvæ clustered around and in three or four egg masses. Some of these larvæ were quite small, while others were of good size, ready to pupate, and while a few larvæ had pupated under the cottony material, most of those found at this time occurred in crevices in the bark or in cavities beneath it. The great good which had been done by these larvæ in destroying the eggs and young larvæ of *Pulvinaria* was shown by the small number of the latter which had set upon the leaves at Montclair, as compared with those at Newark, where the *Coccinellid* was more scarce, or to the amount of setting there would have been under normal conditions.

One adult of the *Coccinellid* was also observed at Montclair, and, judging from its appearance, it had just emerged from the pupa.

Also visited East Orange to examine the trees, especially along Halsted street, where the infestation had been very bad the previous year. I found them pretty badly infested in some places, but as they were nearly all trimmed high, it was impossible to examine the scaly twigs. However, I observed a few *Coccinellid* larvæ crawling on the trunks and a few pupæ in crevices in the bark. The *Pulvinaria* egg masses, too, appeared somewhat torn, but not as much so as at Montclair, and, altogether, it seemed as if conditions might be similar to those in Newark.

June 30th, I examined the material collected at Montclair and made careful search for eggs of the *Coccinellid.* None were found, although larvæ in all stages, as well as several pupæ, were observed. The egg masses and most of the scale larvæ had been pretty well de-

stroyed, so that there were very few of the latter crawling about. The breeding females had also been eaten out, but this was doubtless a secondary attack, after the eggs were laid, rather than due to the *Coccinellid* larvæ, as the females, after depositing the eggs, dried up. In one place, under a cottony mass, I found three parasitic pupæ, and in one of the breeding females I found a pupa and a couple of parasitic larvæ which resembled very much those of *Coccophagus lecanii.*

July 5th, a box of infested twigs was received from Englewood. There was a *Coccinellid* pupa in the box, and several larvæ were feeding on the *Pulvinaria* egg masses. Apparently they had destroyed the eggs and larvæ to a large extent, and if they were as abundant in Englewood as indicated by this sending, the conditions there must have been similar to those in Montclair.

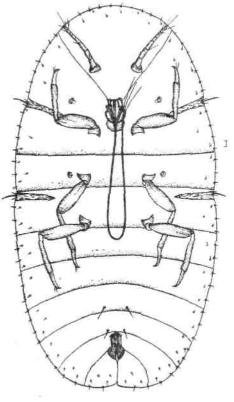


Fig. 33.
Young just set, after the first moult; much enlarged. Original.

The next visit to Montclair and East Orange was on July 6th. In both places the *Coccinellid* larvæ were still found in various stages, but more pupæ occurred, and, contrary to my first observations, most of them were under the cottony masses rather than in the bark crevices.

July 7th, a few beetles were observed in the box in which the pupæ were observed June 24th, so that the duration of the pupal stage is about two weeks. July 10th, when the jars in the laboratory were examined, 150 beetles were found, the insects proving, as previously surmised, *Hyperaspis signata* Oliv., a small, nearly round and convex, black "lady-bird" beetle, with a single red spot on each wing cover. *Most of the pupæ were found in the "eaten out" cottony* masses of the *Pulvinaria,* while a number were in the dry, curled-up leaves. In the latter places there would often be from half a dozen to a dozen clustered together.

About this time infested twigs were received from Elizabeth, and

in one of the cottony masses was found a larva which may have been that of *Lætilia coccidivora* Comst., a *Lepidopterous* insect that is sometimes found feeding on this scale.

July 11th, again examined the infested trees at Montclair, and found them in the same condition as the twigs at the laboratory. On many trees a few beetles were on the trunks, while several were on the infested twigs and branches, sometimes resting in or on the cottony masses or on the under side of the leaves, and observation showed that the beetles climbing up the trunks were those which had emerged from pupæ in the bark crevices. Apparently a large proportion of the beetles had emerged, but there were still a few pupæ, and a very few young larvæ were found crawling on the trunks of the trees.

At South Orange and Maplewood the *Coccinellid* was also plentiful on infested trees, but on the whole not so far advanced as at Montclair, a much larger proportion being in the pupal stage. Here, too, nearly every egg mass of *Pulvinaria* was or had been infested, and it was in these that most of the pupæ were found.

About this same time a few infested trees on Townsend street, New Brunswick, were examined, and conditions were found somewhat similar to those in other localities. Although the scale was not as abundant as in the worst infested places, yet there was considerable setting of larva on the leaves. Neither was its enemy, *Hyperaspis signata*, mostly in the pupal stage, as plentiful.

July 15th, some of the beetles were placed in a jar together with leaves on which *Pulvinaria* larvæ had set, and the beetles soon began to devour the young scales.

It being now evident that the *Pulvinaria* occurred throughout the region between Newark and New Brunswick, it was deemed important to know the extent and amount of infestation. Accordingly, on July 17th, I went by trolley from Newark to New Brunswick. In most of the places through which I passed, namely, Newark, Elizabeth, Roselle, Westfield, Plainfield, Dunellen and Bound Brook, very little or none of the infestation was seen along the trolley line. Going into Elizabeth and coming out a little infestation was observed, and a greater amount occurred on a small group of soft maples between Roselle and Westfield. At certain spots in Elizabeth and Plainfield a rather bad infestation was observed on old trees, but here, as elsewhere, the infestation was irregular. As the trees were large and the branches high, I could not see how prevalent the *Coccinellid* beetle was, but I found a few specimens crawling on the trunks. In Bound

Brook there are a number of fine, large silver maples, but there were no signs of the *Pulvinaria* anywhere in the place.

A day or two later a report was received from Mr. Charles Whitehead, of South River, stating that the scale was very abundant on his trees and had caused a dropping of leaves. Upon investigation I found that the insect had been plentiful on his large silver maples, but more so on some trees than on others, and that most of the infested wood had been removed. However, I obtained a few infested twigs and found that here, also, the *Coccinellid* was present, a few larvæ and pupæ being observed in the egg masses, while on leaves on which a number of scales had set were a few adults. These trees were the only ones in South River upon which the scale was observed.

Placed all the beetles which had been collected and brought to the laboratory in one jar, with some leaves infested with *Pulvinaria* sets for them to feed upon. A few days later these leaves, which had dried up somewhat, were taken from the jar and carefully examined for eggs of *Hyperaspis*, which should occur if there was a second brood; but no eggs were found. The beetles appeared restless until fresh, infested leaves were placed in the jar, when they settled down and began feeding upon the young sets.

July 24th, on infested leaves at New Brunswick, it was found that a few sets on each leaf were parasitized. These resembled those of the hibernating insects, except for their small size. They were much more convex, plumper and darker than the normal sets on the same leaves, and upon examination I found parasitic pupæ. Some, of a lighter color, a few of which I found resembling the dark forms, but a little softer, contained the parasitic larvæ. The parasitized scales were placed in a bottle to bring the parasites to maturity, while the rest of the sets were placed in the jar containing the beetles, to serve as food. For the most part the beetles were resting within the dry, curled-up leaves, and the majority were as active as ever, only a few having died.

At Montclair, July 25th, I observed less of the scale than on the previous examination. On many leaves not more than two or three sets were to be found, while scarcely a leaf contained more than a dozen, and part of these were parasitized, so that the adult beetle had done very effective work in destroying the sets. The *Coccinellids*, however, did not appear as abundant on the leaves at this time, although there was a slightly larger number on the trunk and several were resting near the cottony masses. Two were found in the masses,

resting in the pupal skins, and, consequently, had become adults within a few hours. However, the great majority had emerged several days previous, as not a live pupa could be found.

In East Orange conditions were similar, except that there were more sets on the leaves, owing, undoubtedly, to the fact that the *Coccinellids* had not been as abundant. Both on the trunks and in the cottony masses a careful search was again made for eggs of the beetle, but none was seen. None of the *Coccinellids* was observed in copulation either on the trees or in the jars at the laboratory.

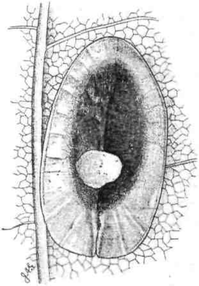


Fig. 34.
Parasitized Scale on a leaf; shows characteristic discoloration and hole from which parasite has issued; enlarged. Original.

There was apparently an extended period of hatching of the eggs of *Pulvinaria*, as larvæ were yet observed crawling on one of the twigs. It was also noted that the young sets were not fixed permanently, but would readily move when urged to do so. When an infested leaf dried up the insects would move to a twig, or if the leaf was lying on the table they would leave as soon as it began to dry and crawl some distance, always toward the light, looking for fresh food.

July 26th, the first adults emerged from the parasitized sets, and on each succeeding day more parasites were obtained. They closely resembled those of the hibernating scales, except that they were distinctly smaller. They were determined as *Coccophagus flavoscutellum* by Dr. Ashmead.

July 27th, a few leaves were collected from slightly-infested trees in Newark. There were only a few of the cottony masses on the twigs from which these leaves had been obtained, but the latter were well set with young. By actual count, I found over 400 on one, and from all appearances this would have been a moderate estimate for the majority of the infested leaves. Apparently the *Coccinellid* had not been present on these trees, and I found this apt to be the case where the infestation was slight. Parasitized sets were also observed on some of these leaves; some bore two or three, while one bore six. All were situated along the veins on the underside, but undoubtedly this was

due to the fact that the majority of sets were on the under side, as previously parasitized forms had been observed on the upper side of the leaf. A few of the parasitized sets showed the holes through which the adults had emerged, so that at this time the parasites were emerging out of doors.

August 1st and 3d, again visited Newark, and on the latter date also Montclair, East Orange and Passaic. In the latter place there are comparatively few soft maples, but some of these showed a slight infestation. In Newark some of the infested leaves showed quite a number of parasitized scales, while others were light in color, showing that the parasite within them was in the larval stage. On one leaf an adult parasite was seen running about.

In East Orange I did not observe any *Coccinellids*, while in Montclair and Newark there were not nearly so many as at the previous examination. In both places I found a single beetle in a dry, curled-up leaf, as if in hiding. A few days later a few sets, some of which were parasitized, were observed on linden and osage orange in Newark.

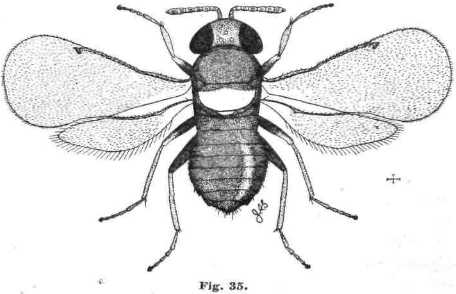


Fig. 35.
Coccophagus lecanii Fitch: one of the scale parasites; much enlarged. Original.

August 11th, some leaves were collected from an infested tree in New Brunswick. There seemed to be few cottony egg masses on the twigs and branches, but the leaves were pretty well set with the young. On one of them I observed a parasite which seemed to be ovipositing in the good scales. It was also noted that some of the scales were slightly narrower than others, and upon examination it was found

that these were males, which were now in the pupal stage, resting beneath the scales. One large leaf, bearing a number of parasitized scales, was examined with the following result:

Total number of scales on the leaf	898
Good scales—apparently females	723
" " " males—in pupal stage	108
Parasitized scales—parasites not yet emerged	32
" " " emerged	35

Judging from the condition of the males, they were mature and ready for copulation.

August 30th, other twigs collected at New Brunswick were examined in a jar at the laboratory. A number of parasites and male *Pulvinaria* was found, and a few of the latter were copulated with the females. As previously observed the insects moved readily when disturbed.

A few days later a box of twigs was received from Plainfield, with the insects in the same condition, while the upper surface of the leaves was quite black and sooty, caused by a fungus growing on the "honey-dew" excreted by the insects.

In Montclair, also, I found that some of the very few scales on the leaves were males, while the female scales were mostly parasitized, so that with the *Coccinellid* larvæ eating the larger part of the eggs and young larvæ, the beetles devouring the young sets and the parasites infesting the remainder, the scale has been about cleaned out where it was so abundant in 1904.

A few infested leaves were collected from trees along South Orange Avenue, in Vailsburg, and on one of them I found 298, while another showed 136 parasitized scales, and many of the leaves showed just as many. Infested leaves gathered in New Brunswick now showed nearly as large a number of parasitized forms.

September 13th, at Irvington, I observed several maples on which there was considerable infestation, and here, as elsewhere, there were parasitized forms. I also noticed that a few of the insects were starting to migrate from the leaves to the twigs. Up to this time the sets had been, with few exceptions, on the leaves, but now a few were observed on the leaf petioles and on the twigs. However, the general migration took place later, and, as it was gradual, was not completed this year until after the middle of October. Even then a few tardy insects were caught and fell with the leaves. Several examinations,

were made after the middle of September, but little or nothing was seen of parasites or beetles, and the latter, in the laboratory, had evidently gone into hiding in the clusters of dried leaves; but owing to the unnatural conditions a number of them died.

The last twigs examined were collected October 25th, from two localities in New Brunswick. In appearance twigs and insects resembled very much those examined in February, and as then, the number of insects upon the twigs varied considerably. Most of the leaves were still on the twigs, and some showed a few live scales as well as parasitized forms. Some of the latter appeared in good condition, but upon opening them I found the parasites dried up. Leaves on the ground also showed live scales in some instances, while the parasitized scales on them appeared similar to those on the adhering leaves.

Life History of the Scale.

The life history of this insect, briefly stated, is as follows: The hibernating females are found along the twigs and branches, generally on the under side. They are oval, slightly elongate, the upper surface somewhat convex and slightly ridged or carinate along the center. They measure about one-sixteenth of an inch in length, and in color are dark brown, except for the slight, secreted waxy layer, which is more or less broken over the upper surface. On the under side, besides the legs and antennæ, a minute, groove-like structure extends from near the base of each of the anterior and hind legs to the lateral margin. From these four areas of waxy substance are produced, that, with the beak, keeps the insect attached to the twig. There are also many minute openings or spinnerets along the margin, and these are espeically abundant in the anal region.

When the sap starts to flow in the spring the insects begin to feed and develop. By April 1st a distinct increase in size is noticed, due largely to the developing eggs, and this continues until the latter part of May or early June, when growth ceases and egg-laying begins. At this time the insect is somewhat lighter in color, about one-quarter of an inch in length and broadly oval, with the upper surface convex. The spinnerets are more in evidence, and from those in the anal region the cottony secretion comes in minute threads.

This secretion, which is really waxy rather than cottony, begins slightly before the egg-laying and continues until the insect has de-

posited between 1,000 and 2,000 minute, reddish-yellow eggs, and has secreted so much that the hind body is raised to an angle of forty-five degrees with the twig. It is at this time—early in June—that the insects become conspicuous, and the cottony masses often remain on the trees for months. Soon after the eggs are deposited the larvæ hatch and crawl to the leaves on which they settle. The larvæ are minute creatures, of about the same color as the egg, oval in outline, with distinct legs and antennæ, and at the extremity of the body two long spines. They generally settle on the under surface, along the veins, but a few get on the upper surface, and very rarely some are found on the twigs. Late in June or early in July the leaves on a badly-infested tree will be thickly set with the insects.

Soon after the young have set two moults take place, and if they are examined later two forms will be found, one somewhat narrower than the other. The latter is the female and the former the male, which passes through a true pupal stage, and during the early part of August reaches maturity. It is then a minute, two-winged insect, which, some time in August or early September, emerges and copulates with the female. The females remain on the leaves, feeding, until after the middle of September, when they migrate to the twigs and settle down to pass the winter. Even under normal conditions many of the insects do not reach maturity, while in some years most of them are destroyed by their enemies.

Enemies of the Insect.

Several enemies of the *Pulvinaria* were found in our examinations, the largest and most conspicuous being the *Coccinellid* or "lady-bird" beetle, *Hyperaspis signata* Oliv., and its larvæ. This was first observed June 15th, when larvæ in various stages were found in newly-formed egg masses. These larvæ, when full grown, are about three-sixteenths of an inch long, white in color, and have the upper surface covered with a material resembling that secreted by the *Pulvinaria,* so that it might be overlooked when resting in one of the egg masses. Often, however, a larva would be found feeding within an egg mass when the latter appeared perfectly normal, except perhaps for a slight enlargement.

Larvæ were observed during the examinations in all the infested localities, but more plentiful in some places than in others. They

were particularly in evidence in Montclair, where, in late June and early July, scarcely an egg mass could be found that was not or had not been attacked by them. Development was somewhat irregular, and some larvæ were found as late as July 15th, but by that time most of them had pupated. The first pupa was observed June 26th, and according to observations in the laboratory, remained in that stage about two weeks. At first the insects appeared to prefer crevices in the bark, but later most of the pupæ occurred in the "eaten-out" egg masses. During July many of the beetles were seen, sometimes feeding upon the young sets, but by the end of the month the majority had disappeared,—presumably into hibernation. The pupa is a chunky, hairy little creature, brown in color, but generally, in whole or in part, covered by the white, secreted material of the larva. The adult is a small, nearly round and very convex beetle, measuring about one-eighth of an inch in length, although varying much in size. It is black, with a single, round, red spot near the center of each wing cover, and in the males has the head, and front and sides of the thorax yellow.

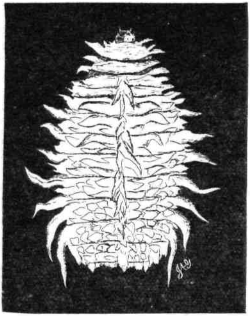


Fig. 36.
Larva of *Coccinellid, Hyperaspis signata* Oliv.: enlarged. Original.

The great good done by this insect was most evident in Montclair, where so many young scales were destroyed that not more than a dozen sets remained on a leaf, where, under ordinary conditions, there would have been between 500 and 1,000.

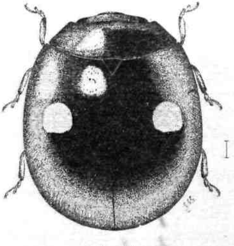


Fig. 37.
The *Coccinellid, Hyperaspis signata* Oliv.: enlarged. Original.

The other enemies observed were minute *Hymenopterous* parasites. The first one noted was *Eunotus lividus* Ashm., a small and very dark

blue insect, with transparent wings, measuring one-sixteenth of an inch in length. Larvæ and pupæ were found in April, in small, stout cocoons, grouped together under the old cottony masses, and the adults emerged late in March and early April.

The other two parasites did nearly as effective work in destroying the scale as did the beetle. The one, *Coccophagus lecanii* Fitch, is about half the size of the *Eunotus*, black, with the scutellum or spot between the wings of a bright yellow, and with portions of the legs light in color. This is parasitic on the hibernating scale; but not until the latter part of April were any such parasitized scales observed. They were readily distinguishable from the live scales by their dark color, more elongate and convex form and smaller size. They were observed among all the lots of insects examined in the trees or in the laboratory, but it was not until near the middle of May that adults were observed. During the rest of that month and during June they occurred more or less abundantly, but toward the end of June disappeared. The efficiency of this insect was apparent in several places, where two or three times as many parasitized as live scales were found.

The other parasite, *Coccophagus flavoscutellum* Ashm., resembles the preceding very closely, and as a matter of fact would be taken for it except for its smaller size. It was found only in the young sets and scales of the summer months. Among scales examined July 24th some parasitized forms were found exactly resembling those of the hibernating insects, but smaller, and in them the parasitic larvæ and pupæ were noted. They became more abundant as the season advanced, some leaves showing 200 or 300, and from all appearances there were several broods. This species, as well as the preceding, was observed in all the infested districts, but much more common in some than in others, and the number of scale insects to go into hibernation has been much reduced.

Another species sometimes observed destroying the *Pulvinaria* is *Lætilia coccidivora* Comst., a *Lepidopterous* insect, the larva of which is found in the egg masses feeding on the eggs and larvæ. In our examinations no signs of it were seen, except, perhaps, on twigs from Elizabeth, July 10th, in which a young larva that may have been this species was observed.

Other parasites and enemies of this scale have been recorded, but if they occur in New Jersey they must be rare, as they were not observed during the past season.

Insecticide Work.

The worst injury that this scale causes on even a badly-infested tree is a dropping of the leaves and the death of some of the smaller branches, although when abundant it makes a tree unsightly. Often much of the infestation occurs on the lower branches, so that by trimming these out much good can be accomplished. However, in some spots where the infestation was very bad the past season, it was apparent that if we could find a material which could be used to destroy the scale while the trees were in foliage much would be gained, and accordingly several mixtures were tried.

The first was a "soluble petroleum." In April several twigs with scale in the hibernating stage were in part painted and in part sprayed, at the rate of one part to twenty-five parts of water. Several days afterwards the insects on those twigs which had been painted were somewhat loosened, and the mixture had penetrated beneath them to some extent, while on those which had been sprayed most of the insects appeared to be in good condition. This mixture was again used May 23d, when parts of some elms and sugar maples were sprayed at the rate of one part to twenty, twenty-five and thirty parts of water. When examined several days later all the leaves had been injured to some extent, so that they were more or less brown and curled, especially with the stronger mixtures. The elms suffered less than the maples and also recovered more quickly.

Kill-O-Scale was used June 9th, on a sugar maple, at the rate of one part to twenty-five parts of water, while some limbs on a Norway and on a silver maple were sprayed at the strength of one part to thirty parts of water. A few days later the leaves on the sugar maple were brown and burned, those on the silver maple were brown and curled at the edges, while those on the Norway maple were only a little spotted. June 10th, a few infested silver maples at Newark were thoroughly sprayed with this mixture, at the strength of one part to twenty-five parts of water. Three days later I found that where the trees had been drenched the scales were apparently dead, but the leaves were brown, curled and many had dropped.

Another soluble oil (Emulsion No. 3) was given a trial June 8th, when a few twigs to which the healthy insects had moved from the leaves were treated, a portion at the rate of one part to twenty-five of water and the rest at the rate of one part to fifteen parts of water. An examination made a few days later proved the insects to be dead.

A few leaves, which were pretty well hit by the spray and bore a number of parasitized scales, were placed in a jar, and later the parasites emerged, showing that the material had not affected them.

Later this same mixture was used on a Norway, a sugar and part of a silver maple. Examination a day or two thereafter indicated that the material had not injured the foliage, except in the case of a few of the younger and tender leaves on the silver maple.

A rosin-naphtha mixture was applied to a sugar maple May 29th, at a strength of one part to twenty parts of water. Several days later I found that the leaves were burned as badly as any of those receiving the strongest mixture of soluble oil.

Two soap mixtures were used. One of these, Tak-a-nap, was applied June 9th to a Norway and a silver maple, at the rate of one pound in four gallons of water. The leaves on the Norway maple showed little or no bad effects, while those on the silver maple showed a very slight burning at the edges. June 15th, sprayed a few badly-infested twigs on which the egg masses were of good size, with Tak-a-nap soap, at the rate of one pound to four gallons of water, and a few others with fish-oil soap, at the rate of one pound to five gallons of water. Next day it was noted that on those sprayed with Tak-a-nap the egg masses were discolored, but very little penetrated, while on those sprayed with the fish-oil soap the solution appeared to have penetrated the egg masses much deeper. An examination made some time later showed the results slightly intensified. Those sprayed with the Tak-a-nap soap remained in fairly good condition, while those sprayed with the fish-oil soap became considerably matted and lost their cottony appearance. However, *Pulvinaria* larvæ, as well as parasites, were obtained from both lots of twigs, so that neither material was thoroughly effective.

June 19th, used the fish-oil soap, at the rate of one pound in four gallons of water, on a silver maple; at the rate of one pound to five gallons on a silver maple and a sugar maple, and at the rate of one pound to six gallons on a sugar maple, with the result that the leaves on all the trees were more or less injured.

It is apparent from these experiments that a mixture strong enough to destroy the insects, except as larvæ or recent sets, would seriously affect the foliage. Recent sets and larvæ may be reached by comparatively weak mixtures, but as the period of emergence and setting lasts about six weeks, it is not practical to spray. Moreover, by the

application of summer mixtures, many *Coccinellid* beetles, as well as their larvæ and pupæ, would be destroyed, although those protected by the cottony masses and the parasites would not be. Thus it is evident that spraying operations against the scale must be carried on in winter, while the trees are dormant. At that time any of the soluble petroleum preparations, kerosene emulsion, lime-sulphur or soap mixtures will be effective when used at winter strength.

Distribution of the Insect.

A point of interest is the extent of territory in this State now infested by the insect. This is from Englewood and Passaic, on the north, to New Brunswick and Keyport, on the south, and lies east of the Watchung mountains. It is interesting to note, also, that throughout all the infested region the enemies of the scale were found with it, and undoubtedly will reduce it next season in the same manner that they have done this year at Montclair. As a result, the insect will probably not be as abundant again for several seasons.

Practical Suggestions.

From the observations recorded by Mr. Dickerson it would seem that, in general, the natural enemies may be trusted to gain control of this cottony scale before it has caused serious injury to the tree. It is indicated, further, that summer applications of insecticides are not practical, but that winter treatment would probably be effective. *The difficulty would be in the cost and in getting the work* thoroughly done.

The East Orange Shade Tree Commission has solved the problem by mechanical means. They spray there with water only, and direct a small, solid jet at the developing cottony masses, readily dislodging and scattering them. An insect in that stage, once dislodged, cannot regain its hold, and larvæ hatching from eggs on the ground are incapable of making their way to the trees. I have very generally recommended the use of a garden hose, with a solid jet, wherever city water pressure was available, and as the infestation is usually on the lower branches and on the under side, that works in most cases.

Where water pressure is not available a solid jet from a pump will answer, and the jet need not have over one-sixteenth inch in diameter at the nozzle: it is the force behind the water, rather than the size of the stream, that counts. This application should be made as soon as possible after the cottony masses make their appearance, and before the eggs begin to hatch. The actual time is indicated in the preceding account of observations made.

RECORD OF INSECTICIDE WORK.

Only a part of the experimental work done is here recorded, and that is especially the case with the oil preparations. The object is to give the results obtained, without too much detail, and with yet enough facts stated to show that there is a basis for the conclusions reached. Over a dozen preparations other than those here mentioned were received, and some were not used simply because no satisfactory opportunity developed. These will be tested next season if possible.

In the case of the oil and sulphur combinations, field observations are included, though the applications may not have been made under control. It is as important to know what results the average farmer obtains as to learn what can be done when all factors are favorable. The ideal insecticide is that with which failure is impossible, even in ignorant hands, provided only that the application is complete.

Lime and Sulphur.

The question of just how the armored scales are killed by the combination of lime and sulphur is not satisfactorily settled, and it was suggested by Mr. P. H. Pough, of the T. & S. C. White Sulphur Company, that the lime might be merely a carrier to divide the sulphur and favor decomposition, a result that might be reached by simply mixing very fine sulphur dust with ordinary milk of lime. To test this view, a bag of very fine sulphur dust was sent in and was used April 6th on the College Farm.

Thirty-three (33) pounds of lime were slaked with cold water and diluted until the thick milk of lime was entirely cold, then seventeen pounds of the sulphur dust were stirred in thoroughly, so as to form an even mixture, which was diluted to make about fifty gallons, and sprayed on Standard pears and one side of three rows of apple trees.

July 21st, Mr. Dickerson made a critical comparison and found little difference in effect between the lime, sulphur and soda and the lime and sulphur dust. There was a little advantage for the soda combination, but not a great deal. The infestation was not bad in any case, and both combinations destroyed insects enough to carry the trees safely through the summer.

The sulphur supply in this case was the dust swept from the beams of the works, where it had settled, and was an almost impalpable powder, much finer than the "flowers." The experiment has little practical bearing, but does indicate that no actual chemical combination with lime is needed to produce an insecticide effect.

Lime and Sulphur, Self-Boiled.

The results of the self-boiled lime and sulphur combinations, so far as I saw them in previous years, were so unsatisfactory that I could not recommend them. What I saw in June, in the peach orchards of Mr. A. N. Brown, at Wyoming, Del., and afterward in the apple and pear orchards of Mr. E. S. Holmes, at Riverton, N. J., has convinced me that, with proper care in making and applying, this combination can be effectively used. As to the application, it should be noted that both Mr. Brown and Mr. Holmes use a gas sprayer, with which a good pressure is easily maintained, and use nozzles fine enough to make a satisfactory covering. Both are usually liberal in their applications and unquestionably have shown that they can make a satisfactory mixture without boiling.

The process is as follows: Use forty pounds of lime, twenty pounds of sulphur flowers and fifty gallons of water. The lime should be of the best quality, and flowers, not ground sulphur, should be used.

Place the lime in a barrel and dust in the sulphur with it, so that the two may be well mingled. Add boiling-hot water enough to start a brisk slaking and cover with a heavy blanket to confine the heat. Add hot water as needed, to keep up the slaking, and stir occasionally with a hoe or similar implement. Keep this up until all the lime is completely reduced and mixed with the sulphur. Then let the mixture stand covered for at least half an hour, to maintain its heat; afterward dilute with warm water to the desired strength and spray at once.

Lime, Sulphur and Salt.

This combination has remained the reliance of quite a number of our fruit-growers, and results have been better, as a whole, than during the year previous. On peach and plum some excellent work has been done, and on apple and pear better effects have been obtained in most cases. It seems now, by comparing applications, that the amount of force behind the spray is a matter of great importance. The tendency of the wash, especially when an excess of lime is used, is to form a superficial coating, not closely applied to the surface of either waxy twigs, like those of pear, or fuzzy shoots, like those of apple. The natural inclination is to use a nozzle with large opening, throwing a coarse or fan-shaped spray, which is directed over a tree and allowed to fall down on it in a fine shower or rain. This process covers, of course, but it does not drive the mixture into close contact with the bark or the scales that set close to it. The consequence is that two men may spray two similar trees, equally infested, with the same kind of wash, at the same time, and yet obtain dissimilar results. The man who applies a coarse spray, without much force behind it, may cover a tree as completely as his neighbor, who applies a fine spray with force enough behind it to drive it into close contact with the bark, but in the first case the mixture may wash or scale off without much harm to the insects, while in the latter the insects are directly affected. It seems like a small matter, but it is really, I believe, a vital one, and I am led to that belief because, in all the successful cases examined, I found the lime particles in close contact with the scales and surface. On peach and most plums the surface of the bark seems to favor the adhesion of the lime particles.

As to the formulas used, the tendency has been to lessen the amount of lime so as not to exceed in weight the sulphur; to reduce the amount of salt to about one-third the weight of sulphur, and to reduce the time of boiling, fixing this rather by the appearance of the wash than by an absolute period. There is the same complaint of trouble in making and of the difficulties in application, but as the fittings for preparing the material become more complete the matter of application also becomes better understood.

In some of the fruit-growing districts in Delaware, peach-growers, especially, depend altogether upon this combination, and seem to believe their trees benefited irrespective of scale infestation. I still

believe the formula giving fifty pounds each of lime, salt and sulphur to 150 gallons of water to be the best, though little is lost by reducing the amount of salt by one half.

The caustic soda combination seems to have been little used, and the only definite record that I have is of the application made on the College Farm and recorded in the general review.

Napthol-Sulphur.

As the sulphide preparations have proved to be effective scale destroyers, and one of the chief objections to their use is the task of preparing them, it is natural that chemists should try to get a concentrate that would simplify the use of the material.

A small sample of Napthol-Sulphur, in paste form, was sent in, and applied March 6th, on a bright, sunny day, with a moderate wind, on trees 19, 20, 31, 32, 33, 34, 42, 44 and 47 of the Experiment Orchard. The dilution was, as recommended, to give the theoretical strength of the normal lime, salt and sulphur wash. It mixed easily in water, sprayed freely, and left the trees with a greenish-gray covering. The application was well made, and the drip discolored the snow to a uniform yellow. Trees 32, 33, 34, 44 and 47 had been sprayed in October with Kill-O-Scale, and must be left out of consideration in estimating the value of this mixture.

June 25th, the trees were examined and no appreciable benefit was noted—indeed, tree 19 shortly became the worst on the place, and received early summer treatment. The results were not encouraging in any case, and no further attempt to use the material was made.

Soluble Petroleum.

There are at present four distinct forms of what may be roughly termed soluble petroleum upon the market, differing somewhat in the percentage and grade of oil used and in the emulsifying agent. If we include the "Textil Oil," which is not primarily intended as an insecticide, there are five. All of these combinations mix readily with water, form a milky emulsion and spray and cover perfectly.

The composition of "Kill-O-Scale," of "Scalecide" and of the "Target Brand Scale Emulsion," I know, approximately, from the makers, and these I have tested personally, more or less thoroughly.

"Sure-Kill" I know nothing about from personal experience, and have no direct knowledge of its composition. It seems to be somewhat unlike the others in the character of the oil used, but may be just as effective. But these combinations by no means represent the number of those that were actually made, tried and rejected. "Kill-O-Scale" is sold by the Griffith & Turner Company, of Baltimore, Md., and was, up to the present season, the best, as it was the first combination regularly upon the market. It differs from the others in containing an appreciable amount of free sulphur, and it has approved itself a safe and reliable insecticide. But even this is better now than it was when first put upon the market, and the emulsion is more stable. On this point of stability there is something left to be desired, and all these combinations should be used as soon as possible after their receipt, and none should be exposed to freezing, or even low temperatures, if it can be avoided. Mineral oils in any form or combination work best in warm weather, while the emulsions tend to separate at frost lines.

The makers of the "Kill-O-Scale" have afforded me every opportunity of making a thorough test of their product, and have been liberal with samples for experimental purposes.

"Scalecide" is made by the B. G. Pratt Company, of 11 Broadway, New York, and while it is an independent development, it is, in essential composition, not unlike "Kill-O-Scale." From this firm I had a great variety of combinations; some made from Texas crude, some from Pennsylvania crude, and some from distillates of all grades to high-test kerosene. "Scalecide" is the outcome of these experiments, which have shown that any grade of mineral oil may be prepared so as to be readily miscible in water. Experiments are yet in progress which will, it is hoped, produce a material that may be safely used in summer, when plants are in full foliage.

The "Target Brand Scale Emulsion" is sold by the American Horticultural Distributing Company, of Martinsburg, W. Va., and is the result of a long series of experiments made by their chemist, Dr. P. Karntz. The method of securing the emulsion is quite different from that of the other preparations, but the percentage of mineral oil is approximately the same. Dr. Karntz has prepared for me several samples of oil combinations in quantity sufficient for practical tests, and if not all of these are reported here it is simply to prevent overburdening by a record of failure, which are important only because they resulted in final success.

All the preparations above named contain about 60 per cent. of actual mineral oil. All are to be diluted with twenty parts of water for winter work, and all may be expected to give a similar result. As to "Sure-Kill," sold by Siebrecht & Son, 425 Fifth avenue, New York, it may be equally reliable, but there has not been opportunity to test it. I have no knowledge of how this was developed.

The experiments made with the "Target Brand Emulsion" are not recorded, because the material now on the market under that name is an altogether different preparation, better, I think, from the material applied by me. It would be obviously unfair to credit the new material with the successes of the old or to charge it with the failures, while a record of experiments with a material no longer on the market is futile.

Textil Oil.

When I first began to urge the importance of obtaining a soluble petroleum upon those chemists who had manifested an interest in the subject, I was informed that there was already such a combination in existence and in use in the trades. It was something known as "Textil Oil," used in softening the fibers of certain fabrics and said to be very poisonous.

I succeeded in obtaining a very small sample of this material, reported to be made up of 70 per cent. mineral oil (petroleum in some form), 20 per cent. animal oil (character not given), 10 per cent. alkali and water.

About the most scaly tree I had on the place, and the one I cared least about, was No. 1, Mariana plum, and I determined to sacrifice that to the oil should it prove as poisonous as it was said to be. From the records of the Experiment Orchard, in the Report for 1904, page 606, it appears that on October 15th of that year, after a series of unsuccessful applications, the tree was in such condition that I sprayed it with "Kill-O-Scale," one part in twenty of water. November 2d, "there were no larvæ and no recent sets, and wherever examinations were made the insects seemed to be dead. Where the scale scurf is thickest it now comes off in soaked flakes, and this last application has been, without doubt, the most effective application of the year. There is little doubt, however, that there are yet enough living scales, well out on the twigs, to provide for a brood in 1905, unless winter applications are made."

The last sentence of the record determined the application of "Textil Oil," and on Saturday, March 4th, Mr. E. L. Dickerson treated one side of the tree with an atomizer, using one part in twenty of water and seeking to give to all the infested growths a careful dose of the spray. The wind being high on March 4th, only one side of the tree was sprayed. March 6th, the rest of the tree was sprayed in the same proportion, but with a compressed air sprayer, through a Vermorel nozzle. The entire tree was, in fact, sprayed at this time, but the heavier application was made from the side which had not been reached on the 4th. The result was, a tree so clean that up to the end of August not a live scale was seen on it. There was no appreciable injury to the fruit buds and certainly none to the tree. Only two fruits reached maturity, but that has been, practically, the record of past years as well, and there was bloom sufficient for a full enough set had it made properly.

Of course this application is not so conclusive as it would have been had there been no "Kill-O-Scale" applied in October, for it is impossible to say definitely how much good that did. That it was very effective the record shows; that I considered winter spraying necessary at the November examination is also shown. Practically, there was a double application of soluble petroleum, with results that were as nearly perfect as could be reasonably expected. "Textil Oil" carries more petroleum than "Kill-o-Scale," forms a milky emulsion with water and sprays perfectly.

Kill-O-Scale.

The report for 1904 contains, on pages 646 and 647, a brief reference to this material and the results that had been obtained from its use up to that time. The conclusion then recorded was: "Certainly we have come nearer to a preparation of petroleum which may be diluted with water, and it offers the best chance of a satisfactory effect of any of the preparations now on the market, though at a somewhat unreasonably high cost."

The conviction expressed in this paragraph has been verified in every particular. Partly by purchase and partly by the courtesy of the Griffith & Turner Company, of Baltimore, Md., material was secured for use in the Experiment Orchard, on the Marsh orchard, the Howell orchard, the Dickerson orchard and the Barton orchards. The

Marsh, Howell and Dickerson orchards are in Morris county, and are mostly peach. The Barton orchards are in Burlington county, and are mostly peach and some apple. In addition, several other orchards, mostly apple, were treated in various parts of the State at varying times and under varying conditions.

The experience obtained in the past and a close watch on the developments of the present season made it possible to explain almost every bad and every good effect that was obtained.

The records of the Experiment Orchard and of the applications in the Marsh peach orchard are detailed in the report for 1904. It remains to add that in both cases the work was nearly perfect. The details as to the Experiment Orchard for the present year are given elsewhere in this report. In the Marsh orchard, on the trees that were twice sprayed before they became dormant, scarcely a live scale had been seen up to late August, and those that had been sprayed once only were almost as good. The single spraying was made just before a heavy rain, and it may be that this exerted some influence.

In the latter part of March some 900 trees, mainly peach, but also some apple and pear, were sprayed in the Dickerson and Howell orchards, near Chester, most of them with "Kill-O-Scale," but some, also, with "Anti-Scale," or its precursor. This lot of material had been exposed to a very low temperature, and one barrel of "Kill-O-Scale" had become partly separated, so that there was some free oil in the mixture. That this influenced the result was shown in the July examination, in which it appears that a slight scattering of scale remained throughout the orchard, but nowhere enough to make summer treatment really necessary.

In the Howell orchard the trees were perhaps a little the worse infested, but these were sprayed last, with fresh material, which had not been exposed to frost, and which mixed without a trace of free oil at the surface. Here the results are almost as good as in the Marsh orchard, though the original infestation was not nearly so bad. In any event, there were nearly 1,000 peach trees treated in late October or late March, and no appearance on any of injury to trees or fruit set, while the scale was as nearly wiped out as any single application can ever hope to accomplish it.

Five barrels of diluted mixture were used in a neighboring orchard of apple and pear trees, in comparison with lime, sulphur and salt, and in midsummer the oil proved to have been much the most effective.

Except the last, the above applications were made by or under the direction of Mr. E. L. Dickerson, my assistant as State Entomologist, or Harold O. Marsh, who had acted as field and office assistant during the summer of 1904. Mr. Dickerson, in his notes on the applications, remarked that "where plenty of pressure was put on the pump and the spray was driven into the tree, it adhered much better and covered much more completely:" and this was before attention had been specifically directed to this point.

A barrel of "Kill-O-Scale" was sent into Burlington county and was used experimentally on a variety of trees in two or three different orchards. These applications were not under control, were in part put on as side issues, and were not as effective as they should have been. Good and even excellent results were obtained, but they were not nearly so complete and convincing as those obtained in the orchards dealt with under direct supervision.

A very interesting observation was made in an old apple orchard near Bound Brook, which was sprayed by a local nurseryman with material ("Kill-O-Scale") furnished by the owner. I was advised of the time when the spraying would be made and sent Mr. Dickerson to watch it. It proved to be an excellent illustration of how spraying is often done, and I advised the owner at once that he must not look for satisfactory results. The object seemed to be to get over the greatest number of trees in the least possible time, and whenever the spraying rod had been over as many movements as might be reasonably required for a covering, the work was considered finished. Such work is bound to be unsuccessful, no matter what the material applied, and it is regretfully concluded that much of the work usually done is of this same general character.

Nothing will be gained by recording duplications of the results already given: some are favorable and others unfavorable; but the central fact remains that, diluted with twenty parts of water, this "Kill-O-Scale" will kill the pernicious scale at all periods of the year—though most certainly in fall: provided always, of course, that the mixture actually reaches the insects aimed at.

For summer work "Kill-O-Scale" is absolutely useless. I tried it at all sorts of strengths on foliage of all kinds and always with bad results. The experiments were not confined to fruit trees, but were extended to the ordinary shade trees, upon which the effect was identical. The actual percentage of oil in a dilution with thirty parts

of water is so low that it would seem as if it could harm nothing, but the combination that makes it effective against the scales evidently makes it hard on foliage as well—especially when the latter is in the growing stage. When the leaves are fully mature they seem to suffer little.

The matter of price may be alluded to, because it is an important one to the farmer. At $1.25 per single gallon, with expressage added, a spray gallon would cost about eight (8) cents, or altogether too much for orchard work, in comparison with the two (2) cents for the lime, salt and sulphur, or five (5) cents for K.-L. For the garden with small trees it will answer very well; for an orchard of old apple trees it is prohibitive. It is fair to say that there is a material reduction in price in barrel lots, but at even the best figure quoted the cost is very high when the necessity for thorough applications is considered.

Scalecide.

This is the outcome of a series of experiments made at my suggestion by the B. G. Pratt Company, 11 Broadway, New York, and the material now on the market has not been practically tested by me personally, but the other preparations leading up to it have been tested, and in each successive lot the defects of the preceding samples have been corrected. The company was good enough to send me, at my request, a list of the New Jersey purchasers of five-gallon lots or more, and I have communicated with nearly all, and have been over the treated trees in several instances.

Among the materials used in combination were Texas crude, Pennsylvania crude, various distillates and refined kerosene. "Scalecide," as it is now, is based on a distillate, combined with a sulphonated oil and a percentage of rosin.

Some ten gallons of Texas oil, made soluble, were tried in the Dickerson peach orchards, near Chester, in comparison with "Kill-O-Scale." The material was exposed to cold and did not mix so well as other samples, partly due, perhaps, to the asphalt base. Nevertheless the results were good and there was no sort of injury to the trees. It was decided, however, that this Texas oil would not work up as satisfactorily as the Pennsylvania type. The dilution was one to twenty, as with "Kill-O-Scale."

A ten-gallon lot, based on Pennsylvania oil, was sent to Mr. D. D. Denise, at Freehold, and he distributed in smaller quantities to several of his neighbors. The treated trees were seen by me in late May, and the results were as variable as the men that did the work. Where the treatment was thorough the result was good; but the bulk of the application has been made in a young apple orchard, sprayed from one side only. As a test of effectiveness this could not be considered at all; but incidentally it was determined that the soluble petroleum did not creep or spread so well as the undiluted crude, with which the balance of the orchard had been treated. The crude oil discolors the surface so markedly that it was easy to see just about how the application had been made and how much the oil had soaked around the limb or branch. This was always considerable, and in smaller branches was sometimes complete. Occasionally a limb would be ringed with the oil in places, and an almost perfect record of the delinquencies of the sprayers could be worked out. The marks left by the soluble oil are much less conspicuous, but are traceable, and nowhere was there anything like the same amount of creeping just above described, though there had been some spread.

To test the oil under conditions somewhat unlike those in New Jersey, I sent a lot of the Pennsylvania mixture to Mr. A. N. Brown, Wyoming, Del., and saw the apple trees to which it had been applied, June 16th, after the breeding had started. Although there was no especial difficulty in finding live scale, and a few larvæ were observed, it was obvious that the results had been very good, and in August Mr. Brown told me that, whereas in 1904 he had no salable apples from these trees because they were so scaly, he expected this year to harvest them all in good condition. Mr. Brown made his application very thoroughly with a gas sprayer, and the fact that the results were not more complete indicate the difficulty of reaching all parts of a vigorous, good-sized apple tree. I have no doubt that all the scales that were actually reached by the oil were killed, and the survivors are simply those that escaped the soaking in some way.

Mr. S. B. Ketcham, of Pennington, received five gallons of the Texas product and applied it March 18th with very satisfactory results. Mr. Ketcham has had some very unfortunate experiences with the caustic qualities of lime, sulphur and salt, and expresses himself as especially gratified with the ease and simplicity of preparations and application.

Eight of the parties who purchased "Scalecide" directly received the product which is now on the market, and in every case the response indicates satisfaction with the product. One orchard examined by myself did not give so good a record, and this was where the largest amount of the material had been used. It seems probable that low temperature and the method of application were somewhat in fault here, because the K.-L. was completely ineffective, also, and none of the applications were really satisfactory.

On the whole, the record is not quite equal to that of "Kill-O-Scale," which had, however, a much more thorough test under somewhat more favorable conditions, in that fall applications were made.

The price of "Scalecide" is $1 per single gallon, and in barrel lots fifty cents, F. O. B. at New York. This brings the cost down to a figure that makes it available for orchard work.

Kerosene Limoid or K.-L.

This combination is made by adding four pounds of limoid to one gallon of kerosene and stirring thoroughly until a sloppy mass is formed. If then a little free oil appears on the surface, add a little more limoid and stir until it is completely taken up and no more oil appears. Add water to equal the amount of kerosene, stirring constantly and hard. Then, after this forms an even mixture, add water sufficient to reduce to spraying strength, *i. e.,* if a 20 per cent. mixture is desired, four gallons of water should be added to every gallon of kerosene used. When all the water is added, stir violently by pumping the mixture back into the spray tank until a smooth, even emulsion is formed, that is quite stable and sprays readily through the finest nozzle, provided no foreign material has been allowed to get into the tank.

Limoid is a finely-ground and very light, dry-slaked magnesium lime: eorson's lime, which is a similar product, has been used for the same purpose; and carefully slaked and sifted dry hydrate of lime does almost equally well. The lime, in its very finely divided condition, takes up the kerosene and forms a carrier, by means of which it is evenly suspended in the water. To be equally effective in all its parts, the diluted mixture must be very thoroughly emulsified, so that there shall be no settling of heavier particles and no free oil. That makes the necessity for the churning process by pumping back into the

spray tank. A properly-made mixture has been allowed to stand over night and was found to be in good shape for spraying next morning.

The lime adds nothing to the kerosene, which is the real killing agent: it is simply the medium by means of which the oil is spread over a greater surface in a thinner film. The quality or character of the lime is therefore only of importance in so far as its fineness and even character are concerned. A lime with heavy or gritty particles will allow the formation of a sediment in the bottom of a tank, which may interfere with spraying.

The combination originated in Delaware and was developed by Prof. C. P. Close, of the Experiment Station in that State. I had the pleasure of seeing the results of some of the work done under his supervision, and he, in turn, had the opportunity of looking over some of the New Jersey results.

One experimental application was made at South Branch, under the direct supervision of the office, on March 18th, 1905, on an orchard of old apple trees. Twenty per cent. kerosene was in the spraying mixture, which was made in strict accordance with formula and directions by Mr. E. L. Dickerson. The combination was readily obtained, and several variations were attempted, none of which equaled that above given, which is in accordance with Professor Close's recommendation. A Gould pump, mounted on a barrel, furnished the power, and the spraying was done through Vermorel triplet nozzles on a gas-pipe rod. After the first day's work the matter was left in the hands of the owner, who did all the mixing and spraying personally, following out closely, so he asserts, the practice shown him by Mr. Dickerson. The limoid running short, 300 pounds of Corson's lime were used, and that gave some trouble because of a gritty sediment. One point developed in this work was that it will not do to leave any spraying mixture in the barrel when a new lot of K.-L. is to be prepared.

June 26th, the results of the work were examined, and, while undoubtedly a very large percentage of the scale was killed, a large percentage was yet alive and breeding rapidly. There could be no question of lack of thoroughness here, because the trees were sprayed from four sides, and the material was yet quite prominently visible on all the trees. As between the limoid and Corson's lime no difference in effect was noticeable. Both applications had done fair work, but too many living specimens remained to make it really satisfactory.

In the Moorestown district of Burlington county, and in the immediately adjoining portion of Camden county, over 20,000 trees, mostly apple and pear, had been sprayed with the K.-L., containing 20 per cent. kerosene. Examined June 6th and July 10th, the results were most disappointing. Larvæ were swarming, recent sets were numerous and some of the fruit was already entirely unsalable. The orchards really were in much worse condition, despite the application, than they had been during the previous summer. Professor Close went over this same territory later, and claims that the poor results were due to the fact that the kerosene and lime were not properly combined; the mixture was made according to formula, but not churned by pumping back into the spraying tank. It was admitted by some of the growers that this was not done, but all of them claimed that they had an apparently even mixture, without obvious free oil. Certainly the results seemed uniform enough to point to a very uniform mixture.

At a number of other places similar imperfect results were noted, and in some cases there seemed to have been a difficulty in getting a good mixture. It seems also as though there might have been some difference in the character of the limoid, because some claimed that they always had a troublesome sediment, and, in two cases, where lots were purchased at different times, one lot was entirely satisfactory and the other showed the sediment.

The other side of the shield was seen in Mercer county, where an orchard of peach and pear, with a few apples and plums, was almost completely cleared of infestation. In this locality 1,000 gallons of kerosene and a carload of limoid was used, with results that were, on the whole, very satisfactory. In some places quite a bit of scale remained, mostly due to incomplete work, and in almost all cases some young and recent sets could be found, especially on apple fruits, but nowhere was there anything like the failure found in the Moorestown region.

The sprayed trees in Delaware were mostly on the orchard of Mr. A. N. Brown, of Wyoming, and were chiefly peach. These were treated under the personal supervision of Professor Close, and the result was about like that in Mercer county—there was some breeding apparent on every tree, large and small, but very little. Later in the season Mr. Brown informed me that, as compared with the lime and sulphur and soluble oil preparation, the K.-L. was decidedly inferior.

This combination should be, theoretically, a very effective one, and and I am not at all sure that good results will not be obtained by using a 25 per cent. mixture in late October or early November.

Kerosene Napthol.

This is a preparation sent in for trial, with directions to dilute with twenty parts of water. The formula sent with the material showed 60 per cent. of petroleum distillate, combined so as to be readily soluble in water—a combination which promised well and which left nothing to be desired as to ease of application. One barrel lot was used on the grounds of Mr. James Neilson, beginning February 25th—in part on a few trees in his garden, but mostly on a long, Osage orange hedge. The outfit consisted of a horizontal lever pump, of much greater power than needed, bolted to a wagon, and pumping from a fifty-gallon barrel to two spray rods with Vermorel nozzles. The emulsion was diluted with two or three times its bulk of warm water, and, when thoroughly combined, cold water was added to make up the quantity. It will be noted that at the dilution given the spray contained a little over 2 per cent. of actual oil, but it was believed that the character of the combination was such that that might be sufficient.

Examinations were made June 27th, and only a very partial effect was noted. There had been some destruction of scale, without doubt, but nothing like the percentage necessary to carry the trees through the summer. The new shoots of the hedge were already well set with larvæ, and promised a worse condition by the end of the summer than existed when the application was made. One plum tree especially, which had been quite badly infested, was swarming with young.

A smaller lot was tried on a few trees of the Experiment Orchard, March 6th, diluted with only ten times its bulk of water. Six trees were treated, but unfortunately five of these had been sprayed with "Kill-O-Scale" in October, 1904, and only one tree, No. 29, could be used as a fair test. This was by no means a badly-infested tree, yet on June 25th scales were noted on the fruit, and a few days later they had become abundant enough to make it advisable to use fish-oil soapsuds in an effort to prevent further infestation.

The outlook was not encouraging, but it was hoped that it might have a field as a summer application. The small balance of material

in my possession was tried on various kinds of foliage when scale breeding began, but much to my surprise the effect was so severe that it was necessary to abandon it altogether.

I am not ready to believe that this combination may not prove a useful one, but it must be much less diluted and must be applied in the late fall, before the scales are dormant. The maker suggests that possibly the mixture had been exposed to freezing weather and had become modified and the emulsion destroyed. It is a fact that this was true of the larger lot, but not of the smaller sample. Nevertheless, the mixture deserves a further test, and, as already indicated, it may do better as a fall wash.

Rose Nicotine.

A four-ounce sample of this was sent in by the manufacturers for trial, with a statement of their belief that it was more active and effective than any similar preparation. It was said to be, not a tobacco extract such as is obtained by boiling and then evaporating down, but a preparation of the nicotine poison itself. The directions for use contemplated two to three tablespoonsful of the extract to ten quarts of water. I used it at the rate of two ounces in eight quarts, partly against apple-leaf hoppers and partly against larval scales. In neither case was there any beneficial result. The application was as thorough as one could be made, and if it were at all useful some benefit should have been noticed; but even the half-grown or larval hoppers, that were thoroughly drenched, minded it not in the least. As for the larval scales, they were no more affected than they would have been by so much water. This is in line with previous results from applications of other tobacco preparations on similar insects.

Dust Spraying.

To speak of a "dust spray" is a contradiction. Nevertheless, the term has made a place for itself and means simply the substitution of some form of dry powder—usually lime—in place of water as a carrier of insecticides or fungicides. In ordinary spraying an insecticide, say Paris green, is mixed with or stirred into a definite amount of water, and the mixture is then spread over a tree in the form of a fine spray, through a nozzle, by the force of a pump. The water, as

such, adds nothing to the Paris green; it is merely the carrier by means of which the poison is spread over a large surface. The water dries off soon after the application and leaves a very fine coating of the dry green. Any other method of producing the same mechanical result is likely to be equally effective. Water is sometimes difficult to get in quantities necessary for spraying purposes, especially in hilly regions or in the arid plains of the central and further west. This has induced an effort to develop dusters in the form of rotary fan-blowers to apply the same poison mixed with the dry hydrate or one of the prepared forms of ground lime. In the form of a dry application on potato vines, New Jersey growers are familiar with the general principle involved, and not a few up-to-date fan-blowers are in use in the State for this purpose. It seems a far jump from a blower to cover a potato vine to one that will cover a tree, nevertheless is has been made, and "spraying" an orchard with dust is no longer a difficult task, even if the trees be of good size.

In New York and in Delaware experiments have been made and reported upon by the Experiment Stations, but there is no record of any considerable number of horticulturists following the method. In New Jersey there are only two of the large orchardists using the dust process, and here I had a chance to see the practical working of the machines. There is no doubt that a tree can be more rapidly covered by a cloud of dust than by a spray, and, when properly made, the application seems to be quite as complete. The work with a good machine is easier, and there is much less carting. A surprising amount of surface is covered by the dust, and its cost per tree is decidedly less than where the liquid spray is used. In the Delaware and New York experiments a double purpose was held in mind, and both copper sulfate and Paris green were used. The New York conclusions are, in brief: Labor and expense of applying dust sprays appears to be less than for sprays in liquid form. Six applications of dust were not more effective on apple than two applications of Bordeaux. Brown rot on peach and plum were not prevented; but the experiments are not conclusive. Dust should be applied in early morning or late afternoon and powder must be strictly dry. Damp, not wet, conditions of atmosphere and tree are desirable, if not essential.

The Delaware conclusion is a little more favorable in the results on apples, and it is believed that for some purposes the dusting may replace liquid sprayings.

In the New Jersey orchards the results demonstrated that, as against the codling moth, the dust was quite as effective as the liquid sprays, and no more applications would seem to be necessary. As to the effect in preventing disease no notes were made, and I have no opinion to offer. An application containing sulphur, applied in midsummer to check scale development, was entirely ineffective.

The present *status* of the matter seems to be that one pound of Paris green or green arsenoid, thoroughly mixed with fifty pounds of fine, dry hydrate of lime, or any one of the prepared or process limes, may be dusted on apple trees with as good results against the codling moth as could be obtained with liquids. The date of application is the same in either case, and three dustings are desirable, though two will answer if the time be properly chosen. If the application is made when the trees are a little damp the material will stick quite as well as the liquids.

As against any leaf-feeding caterpillars or other insects, this method is equally available, and on rough foliage it will be more satisfactory than on smooth or waxy leaves, from which the dust blows or washes easily. The lime alone, or with flowers of sulphur intermixed at the rate of one pound of sulphur in twenty of lime, will be effective against most plant lice, especially the green varieties, and it is probable that fine tobacco dust would be even better.

There is no warrant for believing that any of the dust applications can be in any way effective against scale insects.

RECORDS OF THE EXPERIMENT ORCHARD.

There is a constant decrease in the number of trees in this little lot, due chiefly to the increased size of a few, but also, in part, to a disinclination to replace trees in situations that invite trespass.

After the conclusion of the record for 1904, tree No. 22, which was in a very bad place, overshadowed by No. 35 and by a grapery, was removed and set in the place of No. 46, removed October 1st, 1904. There were no winter treatments.

March 6th, 1905, on a bright, sunny day, moderate northwest wind, sprayed trees 2, 7, 8, 29, 30 and 38 with kerosene-napthol, one to ten. Sprayed trees 19, 20, 31, 32, 33, 34, 42, 44 and 47 with napthol-sulphur, one to thirty-two. Sprayed tree No. 7 with textil oil, one to twenty, applying thoroughly.

April opened warm and forced development. General examinations were made April 12th and 30th, and notes were made at intervals during the month, as individual trees started and developed. At the end of the month and early in May, cold winds and almost freezing temperature checked development until the early start had been neutralized and a normal seasonal development was noted.

May 19th, all the apples and most of the pears were sprayed with arsenate of lead, one pound to twenty gallons of water, until the leaves dripped. On the 25th, used soluble petroleum, one to thirty, on cherry and rose, to kill plant lice, and on the 27th noted that, while most of the insects had been killed, all the foliage was more or less injured. Nevertheless, as a further test, sprayed parts of trees 30, 32, 33 and 40 with the same, one to thirty mixture, and failed later to find any material injury.

May 29th, sprayed all apple trees a second time with arsenate of lead, one pound in fifteen gallons of water.

June 11th, sprayed parts of trees 42 and 43 with Tak-a-nap soap, at the rate of one pound in four gallons of water, to determine effect on foliage as well as on the insects. No satisfactory results noted later.

After an earlier examination to determine condition, examined for scale development June 25th, finding several infested trees on which breeding had not yet started. July 3d, these trees, 24, 25 and 26, were again examined and plenty of larvæ were found: the delay was due to the shaded position of the trees, which seemed unfavorable to the growth of the insects.

July 5th, examined all the trees that were treated with "Kill-O-Scale" October 14th, 15th and 19th, 1904, and found that all were yet free from living young or signs of breeding. These trees, 1, 7, 8, 17, 23, 30, 32, 33, 34, 38, 39, 44 and 47, are all in excellent condition and in strong contrast to those that were untreated. Sprayed trees 24, 25 and 26, and half of tree 2, with soluble petroleum, one to thirty. On the 8th, sprayed Nos. 18, 19, 21 and half of trees 2 and 29 with fish-oil soap, one pound in four gallons of water, producing only a temporary check in each case. At this time the effect of the drought became noticeable, and in spite of occasional watering the dry July materially checked growth.

August 19th, made a general examination for record, and in the evening sprayed trees 18, 19, 21 and 29, and the top of tree 38, with fish-oil soap, at the rate of one pound in seven gallons of water—with

very little good result. Larvæ were moving in great numbers, and it was desired to determine whether a mixture of this strength had any marked effect:—it had not.

August 21st, applied a kerosene and resin emulsion, from Mr. P. Karntz, to trees 8, 19, 20, 21 and 24, as recorded under the tree numbers. There was some difficulty in getting the solution, and next day it appeared that a very uneven piece of work had been done and material injury had been caused. The combination must be improved to be of any use.

August 22d, sprayed trees 15, 16, 23, 35, 42, 47 and 48 with arsenate of lead, one pound in nine gallons of water. Except on trees 15 and 16, the application was chiefly to test the material which had been made in Newark, for the Shade Tree Commission of that city, to replace a lot that had been condemned as unsafe. No injury of any kind developed on any tree and the material was reported as acceptable.

August 26th, all the fruit was removed from all apple trees and from the Vermont Beauty pears. The house was to be shut up for three weeks, and to avoid raids the fruit was removed unripe. Only the Japan Russet pears, quinces and Dwarf Duchesse pears remained.

August 28th, all trees, save peach and nectarine, were sprayed with arsenate of lead, one pound in twenty gallons of water, by Mr. Dickerson. The application was made to prevent injury from fall webworms, one nest of which appeared on tree 3 and other colonies of which were indicated. The application proved effective.

August 31st, sprayed with No. 3 emulsion, one to thirty, trees 19, 24 and 33. This is another of the kerosene and resin mixtures, which worked very well in the pump and mixed almost perfectly. Results are noted under tree headings.

During September no general applications were made, and the insecticides used were all on a small, tentative scale. October 1st, a general examination was made to determine conditions and outline later practice. On the 20th, trees 21 and 40 were cut out, the former because it was crowded out, the latter because it was good for nothing.

October 24th, started with the intention of spraying all the trees, save cherry, walnut and chestnut, with "Scalecide," at the rate of one to twenty; but though there was no wind in the early morning, it arose when the work began and became so high that some trees could

not be sprayed at all and others were incompletely done. A general record was made, especially as regards foliage conditions.

October 30th, all the peach, apricot and nectarine trees were thoroughly sprayed with "Scalecide," one part to twenty parts of water.

November 16th, all the trees were thoroughly sprayed with "Scalecide," one part to twenty parts of water, and as a test of injury, cherry and nut trees were sprayed as well as fruit trees. On the 20th most of the apples and the quinces were yet in pretty fair foliage, but most of the other trees were quite bare.

TREE 1—*Mariana Plum*. The tree ended the season of 1904 in bad condition, with much dead wood and a bad coating of scale. Some of the dead wood was cut out during the winter and some of the scaliest branches were removed.

March 6th, drenched with Textil Oil at the rate of one part to twenty of water, and as the tree had had an application of "Kill-O-Scale" in October, 1904, this made the second dose of petroleum for the season.

The tree had started April 12th, and blossoms were out on the 30th; but development was irregular, both in leaf and blossom, and up to May 11th it was in bad shape. At that time I cut out considerable wood from the inside, shaped up in general and gave the tree a decent outward appearance. But the bloom was straggling; there was almost no set, and not until May 25th was it in full foliage and of a decent appearance.

May 27th, sprayed to a drench from the northwest side with soluble petroleum, one to thirty, to test the effect on foliage, and on the 30th noted that no apparent harm had been done.

As the season advanced the condition of the tree improved steadily, and on the examinations during June and July no scale breeding was noticed. Two fruits matured August 3d, freedom from scale continued during the month, and on September 13th the record was: "Practically no scale. The tree is freer now than it has ever been at this season." On October 1st the record was: "There are some scales; but they must be sought, and at first view the tree seems clean."

October 24th, was yet in full, healthy foliage and looked better than it had for two years past. No dead wood; no coated twigs or branches. Sprayed from the southwest with "Scalecide," one to twenty, and covered as completely as possible by quartering, in a high wind.

TREE 2—*Yellow Transparent Apple.* Was sprayed September 21st, 1904, with soluble petroleum, one to three, imperfectly applied with an atomizer.

March 6th, 1905, was drenched with Kerosene-Napthol, one to ten.

April 2d, the buds were well advanced; on the 30th leaflets were unfolding and blossom buds ready to open, and on May 7th was in full bloom and almost in full leaf.

May 19th, sprayed to a drench with arsenate of lead, one pound in twenty gallons of water, and on the 29th repeated the application. On the 25th a good set of fruit was obvious, and, while the bark looked pretty rough, the tree was otherwise in good condition.

June 2d, the lobes of calyx were closing. On the 25th a few larval scales and recent sets were noticed, but nothing on the fruit, which was developing well. Web-worms (*Hyphantria*) started at several points, but never got beyond the first leaf or two.

July 5th, sprayed with "Anti-Scale," a petroleum preparation, one to thirty, from the house side only, and on the 9th found both fruit and leaves scalded and spotted by the application. Applied fish-oil soap, one pound in four gallons of water, to reach those points that the oil application had not hit. July 9th, the oil injury had intensified, while no harm seems to have been done by the soap. On the 16th there were some worms where apples touched, but none from the calyx end. On the topmost branches some of the fruits were scaly, and these had evidently escaped the sprays. On the 20th and 21st, picked off all the fruits—nearly three baskets—not quite ripe, but very attractive to boys.

As the foliage was suffering from leaf-hopper, sprayed on the morning of July 21st with fish-oil soap, one pound in six gallons of water. A few hours later the leaf-hoppers were as active and numerous as ever. On the 22d, sprayed with soluble petroleum, one to twenty-five, covering very lightly. On the 26th there was no appearance of injury to the trees, while many of the leaf-hoppers had been killed. Nevertheless, these insects were yet abundant enough, in all stages, to discolor the foliage and to cause some of the leaves to drop early in August. On the 19th of the latter month, sprayed with "Rose Nicotine," four ounces in two gallons of water, and applied thoroughly. I actually saw the mixture hit and wet young and half-grown forms, which four hours afterward were as lively as ever. The material was absolutely ineffective.

As to scale, the tree remained quite free until nearly midsummer, though some larvæ were noticed in June. August 19th, I found, on a careful examination, that there were two points well up in the tree which had evidently escaped the spray and from which the insects were then spreading. October 1st there were larvæ throughout the tree, but the infestation was light except on one branch.

October 24th, the foliage was yellow and brown—ready to drop; some already gone—due mostly to leaf-hopper injury. Sprayed with "Scalecide," one to twenty of water, but did not make a good job of it because of the high wind.

TREE 3—*Black Tartarian Cherry.* The tree started to open leaf buds April 12th, began to blossom on the 21st, was in full bloom three days later, was dropping blossoms on the 30th, and out of bloom, with a moderate set of fruit, May 7th. It was not cut back last year, and I attribute the small set to the enormously long shoots to be supported. What was left of the fruit ripened in June, and it was a race between the children and the robins as to which should get each cherry as it colored up. No scale was found at any time during the season, and the tree remained in good condition, save for a little slug work, until November, when the foliage began to drop.

TREES 4, 5 and 6 are out and not to be replaced.

TREE 7—*Champion Peach.* This tree was drenched with "Kill-O-Scale" October 19th, 1904. March 6th, 1905, was thoroughly treated with Kerosene-Napthol, one part to ten parts of water.

April 12th, leaf buds were fully open, blossom buds were well advanced and on the 26th some flowers were open. Was in full bloom April 30th, and in almost full leaf with all the blossoms gone May 7th.

May 7th, the tree was shaped up; the dead wood was cut out, the branches that overhung the fence were shortened back or taken off, and altogether the tree was improved in appearance. The fruit set was good, and while there was considerable drop in June, there was on the 25th as much remaining as the tree should have and no appearance of scale. The same record as to scale continued during July and early August, while the fruit developed as well as the dry weather permitted. August 20th, all the fruit was taken off, just short of being ripe, though fully colored, and at that time a few scale larvæ could be found on close search.

October 1st, was yet in full green foliage, not in the least loosened, fruit buds were making in fair numbers and there was only the merest scattering of scale. On the 24th, sprayed with "Scalecide," one to twenty, the application somewhat imperfect, due to high wind and foliage, which, however, was then about ready to drop.

It should be noted that this was a very scaly tree and so much injured that some branches were already dead or dying. The application in 1904 was made long before the tree was dormant and was believed to be so excessive as to endanger the buds. Nevertheless, a full bloom was made, and all the fruit that the tree should reasonably bear developed normally. I do not credit the Kerosene-Napthol with adding to the effect of the "Kill-O-Scale," and neither material caused injury of any kind. The tree is in far better shape than at the corresponding period last year.

October 30th, yet in full foliage, was sprayed with "Scalecide," one part to water twenty parts, thoroughly applied.

TREE 8—*Grimes' Golden Pippen.* Was treated October 14th, 1904, with "Kill-O-Scale." March 6th, 1905, was drenched with Kerosene-Napthol, one part to ten of water. The tree had started irregularly April 12th, buds were ready to open May 1st, was in full bloom May 7th and out of bloom May 11th. On the 19th sprayed with arsenate of lead *versus* codling moth, and renewed the application May 29th. Woolly lice appeared early in June and some small colonies continued present throughout the season.

The fruit set was not very large, but developed normally except as checked by drought. It began to ripen about the middle of August, and was not Grimes' Golden; but I could get no name for it, and so it must stand as it is for the present. It is very like that on tree 33, marked Baldwin, but that also is untrue to label. In the fruit as gathered August 26th there was no codling moth at the calyx end, but at several points worms had entered where two fruits touched.

Up to August 3d, no scale was seen on the tree, and then a few sets were noted on the fruit. On October 1st, there was very little infestation visible anywhere from the ground, and none that was bad. The effect of the October 14th application was entirely satisfactory.

While this tree did not suffer quite as severely as No. 2, leafhoppers nevertheless became quite abundant on it, and on August 19th sprayed with Rose Nicotine, two ounces in one gallon of water, with absolutely no effect. On the 21st, sprayed with kerosene and resin,

one part to twenty of water, applying thoroughly in the lower part of the tree, but not on the upper shoots, which could not be reached by the little compressed air sprayer used in the experiment. Next day the foliage was brown-spotted, especially on the under side, and the fruit was also brown-spotted where drops gathered. As against the insects the effects were very good; but the material is out of question while fruit remains on the tree.

October 24th, was yet in full foliage, without tendency to drop; sprayed with "Scalecide," one part to twenty of water, but made an imperfect job because of the wind.

TREES 9, 10, 11, 12, 13 and 14 are out.

TREE 15—*Japan Golden Russet Pear*. April 12th, buds were fully developed and flower clusters beginning to show; on the 21st the clusters were separating; on the 27th some flowers were open, and on the 30th was in full bloom—a mass of white flowers. May 19th, sprayed with arsenate of soda, one pound to twenty gallons of water, to guard against codling moth, and on July 21st repeated the application to head off a second brood. A good set of fruit was made, which grew well for a time and then stopped; some beginning to crack early in August, when some leaves also turned yellow and dropped. Later, when the drought was broken, growth was resumed, and soon the branches began bending under their load. September 13th, they were breaking under the weight of finer and better fruit than ever before, and almost free from "worms." Before the crop was off a number of branches were broken by a high wind. August 22d, sprayed with arsenate of lead, one pound in nine gallons of water, to test the material.

As to scale, very little was seen until the middle of July and not much at any time during the season, none at all getting on the fruit. October 15th, the foliage was yellow, ready to drop, some of it gone; not much scale anywhere, and what there was, localized. The tree has really outgrown the trellis and is neither standard nor trained at present. Sprayed with "Scalecide," one part to twenty of water, from one side only, but gave a fair covering to all but a little strip.

TREE 16—*Japan Golden Russet Pear*. The record for tree 15 may, on the whole, answer for this as well. The tree is a little smaller, the crop was not quite so good and there is perhaps a little more scale, but in essentials there is little difference. The two trees together turned in half a barrel of fruit, of no great value except to stew. The

spraying, October 24th, was done more thoroughly than on No. 15, because it was better possible to get around it.

TREE 17—*Trellised Peach.* This received an application of "Kill-O-Scale" October 14th, 1904; began to start slowly and irregularly early in April, and on the 21st some blossom buds were ready to open. Some did open on the 23d, and the tree was in full, if scant, bloom on the 27th. Only one fruit set, and on June 25th, when half grown, began to rot and was taken off. It is smooth-skinned and more like a plum in texture, though obviously a peach in other respects.

Growth was irregular and one branch died, but the other sent out long, vigorous shoots, so that at the end of the summer it seemed possible to get it into usable shape as a dwarf. Plant lice attack became obvious May 25th, and soon after leaf curl developed. The latter persisted until late in June, after the lice had disappeared.

May 25th, sprayed the infested tips with soluble petroleum, one part in thirty parts of water. June 2d, there was no appearance of injury from the oil, nor, on the other hand, did the plant lice show much if any effect: the mixture was too dilute to do either good or harm.

No scales were seen until July 9th, when there was a slight trace that may have come on from the outside, since there were only single small specimens on the new shoots. October 24th, there was still only a scattering, but all over the tree, and enough to provide for a good infestation next year. Foliage still perfect at that time and "Scalecide" was thoroughly applied at the rate of one part in twenty of water.

October 30th, received a second application of "Scalecide," at same strength; foliage still perfect.

TREE 18—*Vermont Beauty Pear.* Started early in April, and on the 12th leaf buds were well advanced and blossom clusters beginning to separate. A few blossoms opened April 27th; on the 30th more than half of them were out, and on May 7th the tree was already beginning to go out of bloom. The set of fruit was small, owing to adverse weather conditions, and on May 26th it was noted that a large percentage of it was infested by the pear midge. This was quite unexpected, as its almost total absence last year led me to believe that it had worked itself out.

June 25th, only a small set of fruit remained, and on this scale larvæ were rapidly setting, there being a full brood in evidence. July 8th, sprayed thoroughly with fish-oil soap, one pound in four gallons

of water. Next day no moving larvæ were seen, and it was hoped that a good effect had been obtained. A week later, however, all the fruit was horribly infested and larvæ and recent sets abounded: only the moving larvæ had been affected by the spray, and breeding had not been even checked. July 21st, sprayed with arsenate of lead, one pound in twenty gallons of water, as against codling moth and leaf-feeders generally. On the 22d, sprayed with fish-oil soap, one pound in six gallons of water, and applied a drench aimed especially at the fruit. July 26th, quite a number of the leaves showed a scalded effect, especially at the edges, but this injury did not intensify, and there was a lessening of larvæ and recent sets, which, however, was due to an intervening period of breeding rather than the insecticide.

August 19th, the fruit was so marred that it was commercially valueless, and a new brood of scale larvæ was present in countless numbers. In the evening, sprayed with fish-oil soap, one pound in about six gallons of water, until every leaf dripped, and I believe every twig and branch was reached. Next day the tree smelled fishy, but there was no apparent injury to foliage, nor was there any lessening of scale larvæ, which literally swarmed everywhere.

August 21st, sprayed with a kerosene-resin mixture at the rate of one part in fifteen parts of water. This was an experimental material, not well combined, and which did not dissolve well in the spraying tank. The last part of the mixture applied seemed almost pure emulsion, and I tried to dilute this by immediately spraying clear water. On the 22d the foliage was pretty well blackened, especially where the settlings had hit, and while a good result had been obtained against the scale, the leaves had been seriously injured. Injury intensified during the next few days, and on the 26th many of the leaves were dead, either black or yellow, as if touched by frost, while the fruit was made absolutely useless. September 13th, much of the foliage was off, the remainder scalded. All save a few badly-speckled fruits were off and on some branches the scale seemed dead; there being plenty left, however, at other points.

October 1st, most of the foliage was off, scale was swarming and there was one bunch of blossoms near the top of the tree. On the 24th the foliage was nearly all gone. There was much dead wood in the tree and it looked and was a serious case. Applied "Scalecide" at the rate of one part to water twenty parts and gave a very fair covering in spite of the high wind.

TREE 19—*Vermont Beauty Pear.* In a general way this has the same history as No. 18, but was never quite so badly infested. It was sprayed March 6th with Napthol-Sulphur, one to thirty-two, the application being thorough enough to discolor the snow from the drippings. There was no appreciable effect from this, and during the summer the arsenate of lead and soap mixtures were applied as for No. 18, and with no greater effect.

August 21st, sprayed with kerosene and resin, one part to water fifteen parts, and made thorough work of it. An attempt was made to hit all the foliage from the outside. The fruits were especially aimed at, and most of the branches were sprayed from below. Some injury developed, but not very much, and the fruits were taken off on the 26th so infested as to be useless. August 31st, applied kerosene-resin emulsion No. 3 at the rate of one to thirty, so thoroughly as to run down the trunk in a stream. The mixture was irregular, and some of it seemed to carry much more resin than others. September 13th, there was quite a bit of burned foliage and some had dropped. The scale situation was not so bad as it had been and some benefit had been derived from the spray.

October 24th, applied "Scalecide," one part to water twenty parts, and covered pretty thoroughly. The tree was not quite so bare as No. 18, but almost as bad in condition.

TREE 20—*Meech Quince.* Sprayed March 6th with Napthol-Sulphur, one part to water thirty-two parts.

April 12th, leaf buds were starting; on the 30th, was practically in full leaf; May 11th, first blossoms were open; on the 14th, was in full bloom, and on the 26th, all the blossoms had dropped. Only a small crop set, but the tree did well otherwise, except that by July 16th it had more scale than ever before in its history. On the 22d, drenched with whale-oil soap, one pound in six gallons of water. At this time the dry weather had stopped all growth except in the developing fruit. After conditions improved fresh growth started, and on August 19th the tree looked very well, though there was a heavy crop of larval scales on the move.

August 21st, sprayed with a kerosene-resin mixture, one part in fifteen parts water, and soaked all parts of the tree. On the 22d the wood looked as if it had been varnished, some of the foliage was discolored and the young and recent sets seemed to have been wiped out. Injury intensified and extended to the fruit, crippling some that re-

ceived the heaviest dose. Yet, though the foliage looked bad, not much of it dropped and some very fair fruits ripened in October, when there was less scale than there had been earlier in the year. October 24th, while yet in tolerably complete foliage, applied "Scale-cide," one to twenty, thoroughly.

TREE 21—*Vermont Beauty Pear.* Its history during the early part of the season was much like that of No. 18, and like that it suffered from the pear midge. Not until almost the last day of June did any scale larvæ develop, but then in a few days they covered every fruit and swarmed on leaves and twigs. The tree was shaded by No. 35, which towered above it, and shoots from the grapevines were running into it, forming a shade that seemed to delay the scale development somewhat. Treatments with fish-oil soap were made and resulted as already noted for No. 18.

August 21st, sprayed with a kerosene-resin mixture, one part to water ten parts, and got over all parts of the tree thoroughly. Little injury to foliage was noted next day, but on the 26th much of it was yellow and some leaves had dropped. The scale situation was not encouraging, and as the fruit was utterly useless it was taken off. September 13th, there seemed more scale than on even 18, and though it still held its foliage remarkably well, October 1st I had it taken out. It would have been quite possible, I think, to conquer the scale, but the position of the tree was such that it could not grow properly and was really in the way.

TREE 22—*Japanese Chestnut.* This is another of those trees that was so shaded by No. 35 and the grapevines that it was taken out and set in the place of No. 46, under which number the record will be continued.

TREE 23—*Greensboro Peach.* This tree was treated October 19th, 1904, with "Kill-O-Scale," one part to water twenty parts, and had no winter treatment. It started early in April and on the 12th some blossom buds were already showing pink; April 27th, some blossoms open; April 30th, in full bloom; May 7th, practically out of bloom, and May 11th, all the blossoms were gone and the tree was in full leaf. A good set of fruit was made, and while the tree is somewhat lanky, due to its shaded position, it was doing well. The crop ripened during the last days of July and early August and was good in size and quality, a little too tender, however, to make a good shipper when fully ripe.

Not until August 19th was any living scale seen, and then a very slight scattering became apparent, as though from a new infestation or a few survivors. Up to October 1st the specimens were not numerous enough to be obvious and the tree was then still in good foliage.

August 22d, sprayed with arsenate of lead, one pound in nine gallons of water, to test the quality of the insecticide, and no injury of any kind developed on the foliage.

October 24th, foliage yet in good shape and fruit buds developing well; sprayed with "Scalecide," one part in twenty parts of water, and covered fairly well. On the 30th the application was repeated more thoroughly, though the foliage still held on well.

TREE 24—*Greensboro Peach.* Started early in April, leaf buds opening out on the 12th, some flowers open on the 27th, while on the 30th the tree was in full bloom. May 7th was almost, and on the 11th altogether, out of bloom and leafing out well. May 26th, a good set of fruit had been made and a little leaf-curl developed, which remained obvious until the early days of June.

The "June drop" was heavy, but enough fruit to tax the tree remained and developed gradually, so as to furnish pickings from July 25th to August 5th, when it was all off.

This is another of the shaded trees, and no scale-breeding was observed until late June, but in July a brood was on the move, so heavy as to demand immediate attention.

July 5th, sprayed thoroughly with "Anti-Scale," a petroleum preparation, at the rate of one part to thirty of water. Severe injury to foliage became apparent July 9th, some leaves being badly spotted, others turning yellow and dropping. It was questioned, however, whether the dry weather was not, in part, responsible for this premature falling. Early in August the yellow spotting on the foliage disappeared, leaving small, irregular holes in its place. August 19th, so heavy a second brood was on the move that it was deemed wise to spray on the 21st with a kerosene-resin mixture, one part to ten parts of water. As the foliage was thin it was possible to reach most of the branches without hitting the foliage very much, but enough was applied to test its effect. On the 22d the leaves had more holes than before, but otherwise were not hurt. On the 26th injury had not intensified, but there was another brood of larvæ on the move, and I sprayed with emulsion No. 3, kerosene-resin, at the rate of one part to forty of water, on one branch only, to test its effect. August 27th,

no injury was apparent, and while the leaves showed a coating of resin, the scales did not appear to have been much checked. August 31st, sprayed thoroughly with emulsion No. 3, at the rate of one part to water thirty parts. The wind was rather high and I could spray only from one side and quartering—enough to reach all foliage, but not all the wood.

September 13th, more than half the foliage was gone and the rest had numerous shot-holes, but crawling larvæ were few and there seemed to be less scale than at the date of spraying. October 1st, the situation was not much worse in any direction, and the remnants of the foliage hung on well and of good color until October 24th, when the tree was sprayed with "Scalecide," one part to twenty parts of water, but rather imperfectly, owing to a high wind. On the 30th the application was duplicated and much more thoroughly, the foliage yet as before.

TREE 25—*Apricot.* The tree started early in April and on the 12th was one mass of pink buds, just about ready to open. On the 21st was coming out rapidly, and on the 22d was a mass of beautiful flowers. Was out of bloom and growing well May 10th, and that record continued until late in June, when, probably owing to drought, the shoots stopped growing and the foliage lost its bright, vigorous appearance. During the first days of July a heavy brood of young scales was produced, and on the rather close examination then made it was found that there were several well-developed fruits present—two of them already attacked by the rot. As this tree had never set fruit before, none was looked for and thus it escaped earlier discovery. None ripened, though some became fully colored, and all of it was off by August 3d.

July 5th, sprayed thoroughly with "Anti-Scale," a petroleum preparation, at the rate of one part to thirty parts of water. The result was disastrous, the tree being almost defoliated July 9th, and the remaining leaves wilted. Even the now exposed fruits were spotted and suffered as much in their way as the leaves. As to the scale, it was present in all stages, and while some were undoubtedly killed, more than enough remained.

August 19th, the second brood of larvæ developed in goodly number, and the tree did not seem to stand defoliation or injury at all well.

August 26th, applied No. 3 kerosene-resin emulsion, at the rate of one part to forty parts of water, to two shoots, to test the effect on foliage. No appearance of injury on the 27th. The same shoots were sprayed a second time and examined on the 31st. At that time there were few larvæ or recent sets left and some benefit had undoubtedly resulted from the application.

Injury did not intensify, and the scale-breeding seemed to have been decidedly checked on September 13th. October 1st there was only a skimpy lot of foliage, and while there was considerable scale at some points, the bulk of the tree was practically clean. Attempted to spray October 24th, but the wind prevented that. On the 30th sprayed thoroughly with "Scalecide," one part to water twenty parts.

TREE 26—*Nectarine.* Just starting April 12th; first blossom out on the 27th; full bloom April 30th; out of bloom and in full leaf May 11th. A rather bad attack of leaf-curl began to develop at this time, accompanied by gummy exudations from some of the branches, so that by the end of May it looked rather ragged. During June conditions improved until about the last of the month, when a very heavy brood of young scales made its appearance and in early July demanded attention.

July 5th, sprayed thoroughly with "Anti-Scale," at the rate of one to thirty of water. Injury developed during the days next following and some of the foliage dropped. Many of the scales were killed, but the brood was so tremendous that some remained over and new larvæ were again numerous July 9th. Some of the remaining leaves were badly spotted and these spots formed holes as the season advanced, giving the tree a ragged appearance.

A small set of fruit was made, which developed very slowly, and not until about the first of October did it mature about a dozen indifferent fruits of irregular size.

August 19th, the second broom of larvæ was in evidence, and later the tree was always full of moving young and recent sets. The foliage was still in very fair shape October 24th, when most of the trees were sprayed, but high wind prevented application to this. October 30th, sprayed thoroughly with "Scalecide," one part to water twenty parts.

TREE 29—*Gravenstein Apple.* On March 6th, sprayed thoroughly with Kerosene-Napthol, one part to ten parts of water. The tree started early in April, leaf buds pointing out on the 12th, while the

first flowers opened on the 27th. Bloomed very full, but rather irregularly, some petals dropping May 7th, when some buds were not yet open.

A heavy set of fruit was made, and on May 19th sprayed with arsenate of lead, one pound in twenty gallons, repeating at the rate of one pound in fifteen gallons, on the 29th, until the foliage dripped. The fruit developed normally until, August 3d, the tree was almost breaking under its load. Left directions to thin, which were misunderstood, and almost half a barrel of unripe fruit was removed. On the 19th I had the balance taken off, almost a barrel being harvested. Though unripe when picked, the fruit matured very nicely in the cellar and was all used. But it is not a Gravenstein, and just what it is I could not determine. There was practically no codling moth and only a speckling of scale. So far as condition and appearance went the fruit was first-class, but it was undersized.

As to scale, the tree was not badly infested in 1904, and received no radical treatments; the March application of Kerosene-Napthol was scarcely to be credited with much effect, and yet very little scale was seen June 25th. Sprayed from one side with fish-oil soap, one pound in four gallons of water, and up to the middle of August very few larvæ or recent sets were noted.

August 19th, just before the fruit was removed, I noted that the upper portion of the tree was becoming speckled, and as leaf-hoppers were making themselves conspicuous, I sprayed with Rose-Nicotine, two ounces in one gallon of water, to note its effect. With that end in view I literally soaked the tree, drenching scale larvæ and leaf-hoppers equally. When all was dried off none of the insects were any the worse for their bath, and in the early evening sprayed with fish-oil soap, one pound in seven gallons of water. This seemed to be quite as harmless as the Nicotine, and I let matters go without further interference.

October 1st, the foliage was beginning to brown up, but all was yet fast and good. The trunk and main branches and most of the lower part of the tree were free from scale, but upward and outwardly there was more infestation. On the 24th the foliage was beginning to thin a little, and I sprayed with "Scalecide," one part to twenty parts of water, covering quite thoroughly.

TREE 30—*Grimes' Golden Pippin.* This tree was sprayed with "Kill-O-Scale," one to twenty of water, October 14th, 1904, and

drenched with Kerosene-Napthol, one to ten parts of water, March 6th, 1905. Did not start until April 12th, and was moving slowly on the 30th. Was in full but scant bloom May 7th, and made a small set on the 14th. May 19th, sprayed with arsenate of lead, one pound to twenty gallons of water, and repeated the application ten days later, at the rate of one pound to fifteen gallons.

The fruit developed normally and up to the middle of August there was practically no scale on the tree. On the 19th of that month a few fruits showed a trace of recent sets on the side nearest to 31, and there was the merest indication of codling moth.

August 26th, all the fruit was removed, and in view of the fact that this tree was at one time very badly infested, and has had applications of about everything that was ever used, from tobacco to crude petroleum, it will be interesting to note its condition, premising that owing to its premature removal it was undersized. In all there were 109 apples, of which ninety-one were absolutely clean and eighteen showed scales or scale marks. Of the infested specimens seven had one scale only, or a scale mark counted as a scale; six had two scales; three had a sprinkling of small scales, and two had three or more scales of the first brood. Besides this there were two fruits excluded from consideration because they had codling moth—the only wormy apples on the tree. Irrespective of scales, fifty-six of the apples were perfect, thirteen were slightly marred by outgrown curculio punctures, and the remainder were seconds, most of them getting their rank because of curculio marks and spots.

The balance of the season seemed to give added vigor and color to the tree, and on October 24th it was yet in perfect foliage, the leaves of a rich green color and the picture of vigor. Sprayed with "Scalecide," one to water twenty parts, as thoroughly as the mass of foliage would allow.

In view of the past history of this tree its present condition is remarkable and seems to indicate that so long as there is a sound stock and plenty of food the scale can be practically eliminated.

TREE 31—*German Prune.* Sprayed with Napthol-Sulphur, one part to water thirty-two parts. Made a start early in April, buds beginning to show green on the 12th, while flowers opened on the 30th. Was out of bloom and in full leaf May 11th, and made a good set of fruit. The curculio began to get in its work about the middle of June, and early in July fruit began to drop as the result of the attack.

More than half of it was gone at the beginning of August, and as soon as what remained began to show a tinge of color the rot set in. Eventually not a fruit ripened, the rot destroying each before it matured.

Scale larvæ were first noted June 25th, but the brood was not heavy and had ceased running July 16th, at which time some of the foliage had a scalded appearance, due to the spray that slopped over when treating tree 18. July 22d, applied fish-oil soap at the rate of one pound in six gallons of water, and this caused serious injury. Many of the leaves were burned at the edges and were browned, while others wilted, turned yellow and dropped.

Early in October much of the foliage was already off, while more of it was ready to drop at a touch. Some was yellow and discolored, but quite a bit looked green and firm. On the 24th, sprayed thoroughly with "Scalecide," one part in twenty parts of water.

TREE 32—*Mountain Rose Peach.* This was badly infested and sprayed with "Kill-O-Scale," one part to water twenty parts, October 14th, 1904. March 6th, 1905, sprayed with Napthol-Sulphur, one part to water thirty-two parts. The tree started normally in early April and developed as the season advanced. It had no bloom and made a satisfactory growth, all the foliage being still present in late October, when a good set of fruit buds had formed.

May 27th, sprayed with an atomizer, soluble petroleum (sample), one part to water thirty parts, to test the effect on foliage. A little burning and spotting developed during the week following; but not enough to be considered a real injury.

No live scales were found until July 9th, when a few recent sets were seen and these may have come on from the outside. As the season advanced the infestation increased slightly, and in October there was a scattering set throughout. On the 24th sprayed with "Scalecide," one part to water twenty parts, and covered well. On the 30th the application was duplicated with equal thoroughness.

TREE 33—*Dwarf Duchesse Pear.* Was sprayed with "Kill-O-Scale," one to twenty, October 14th, 1904, and with Napthol-Sulphur, one part to water thirty-two parts, March 6th, 1905. During the winter rabbits got at this tree and girdled one of the lower branches, which died in consequence. For some reason this tree is a favorite resting place for the few wild rabbits that come into the garden, and it is the only one that suffers from them.

Growth started early in April, and a few blossoms opened on the 27th. On the 30th was in full bloom and on May 11th was out of bloom, in full leaf, with indications of a moderate set of fruit. From one cause or another the set diminished until the crop consisted of ten pears, harvested late in September.

May 27th, sprayed one of the lower branches with a soluble petroleum (sample), one part in thirty parts of water, to test effect on foliage. Three days later not only foliage but even some of the sappy shoots showed so much injury that the material was discarded for summer use.

August 31st, sprayed with Kerosene-resin Emulsion No. 3, one to thirty parts of water, until the tree dripped from every leaf. No marked injury developed later, and up to late October the foliage maintained its hold. On the 24th of that month leaves began to drop readily and the tree was sprayed with "Scalecide," at the rate of one to twenty parts of water, covering thoroughly.

TREE 34—*Lawrence Pear.* Was sprayed with "Kill-O-Scale," one to twenty, October 14th, 1904, and with Napthol-Sulphur, one to water thirty-two parts, March 6th, 1905. Began to start slowly and irregularly in early April, but toward the end of that month stopped, began to wither, and early in May died off. Just what killed this tree is not clear; it was not scaly enough to endanger its life, and both "Kill-O-Scale" and Napthol-Sulphur were safely applied to so many trees that neither can be fairly charged with its death.

TREE 35—*Japanese Walnut.* Started early in April and bloomed heavily in May, toward the end of which month the spikes were entirely developed. Set quite a heavy crop of nuts, which disappeared mysteriously about the time I expected to gather them.

During midsummer the dry weather caused some of the leaves to turn yellow and brown before dropping, and this thinned out the foliage materially. The tree was not bare, however, until the beginning of November. On August 22d, sprayed with arsenate of lead, one pound in nine gallons of water, to test its effect on foliage. No harm was done, but the application probably wiped out a brood of *Datana* larvæ which developed during the early part of September.

The scale condition is as usual. There are always some half-grown specimens scattered about, but I have found no fully-developed females and no brood of moving larvæ. The appearance is as if the insects were carried to the tree, set, reached the half-grown condition, and then died.

This is now quite a large tree and dominates its surroundings. It is of no value as a nut producer, but it is rather a satisfactory sort of shade tree for the position that it occupies.

TREES 36 and 37 are out and no others were set into their places.

TREE 38—*Baldwin Apple.* Was treated October 14th, 1904, with "Kill-O-Scale," one to twenty of water, and on March 6th, 1905, sprayed with Kerosene-Napthol, one part to ten of water, until fully drenched.

Started early in April, and by the end of the month was leafing out nicely and blossom buds were pink and ready to open. Some did open May 1st, and on the 7th was in full bloom, a mass of pinky-white, which had practically disappeared by the 14th, when a heavy set of fruit was indicated.

May 19th, sprayed with arsenate of lead, one pound to twenty gallons of water, and on the 29th renewed the application at the rate of one pound in fifteen gallons.

The tree developed normally until the end of June, when it was heavily loaded with fruit and no scale could be observed, but during the early part of July a little spotting of the fruit on the extreme top of the tree called attention to the fact that my compressed air sprayer, used in October, 1904, did not quite reach the top of this tree and that a center of infection existed at that point.

August 19th, had half a barrel of apples taken from the tree and that still left too many. In the lower portion most of the fruits are clean, but toward the top the tips show some of the apples to be quite scaly or becoming so from the second brood of larvæ. Some of the apples look very handsome and there is very little "wormy" fruit. In the evening, sprayed with fish-oil soap, one pound in seven gallons of water, aiming especially at those high points that had been missed by the late fall spray and where scale development was most marked. No harm was done to the tree, and it was not possible to determine that any had been done to the scales.

August 26th, all the fruit was taken off, unripe to be sure, but enough to make, with the lot of August 19th, a little less than one and one-half barrels. Although undersized and not colored, the fruit as a whole was fair, and such as was wormy was mostly entered from points other than the calyx.

The general condition of the tree remained satisfactory during the balance of the season, the foliage adhering until early in November.

At that time sprayed with "Scalecide," one part in water twenty parts.

This is another of those trees that was at one time so scaly that it seemed as if it must succumb, and I had actually directed my boy to cut it out. For some reason the direction was not at once obeyed, and I afterward decided to kill it first by experiments and have it removed afterward.

TREE 39—*Trellised Apple.* This did so little in 1904 that it was taken out, and the space was not filled during the season of 1905.

TREE 40—*Lincoln Coreless Pear.* Started early in April, and for the first time blossom clusters developed, some flowers opening on the 26th, while on the 30th was in full bloom—a mass of white. A heavy set of fruit was made, in which the pear midge appeared May 26th, materially reducing it. Only a little remained in June, and this developed irregularly until, in late September, about a dozen pears ripened, two of them of good size and typical form. On cutting they proved to be anything but coreless, and on tasting they proved to be the very worst I ever sampled:—therefore the tree was ordered out and was removed in October.

This tree has had an interesting history, the scale having been allowed to develop unchecked since it was set out. It was noted at once that for some reason the insects did not increase in numbers on it, and in the hope that an exempt variety might be developed, the tree was watched and kept free from all applications tending to decrease scale. As a matter of fact infestation never became very bad at any time, yet the tree undoubtedly suffered. The bark roughened, some of it scaled off, and in some places it split. The outer surface became hard and during the last year the foliage and growth were not up to the standard. This was especially true during the summer just passed, when many leaves turned yellow and dropped, while some small branches died. Whether this is all to be attributed to the scale may be a question; but at any rate the tree had served its purpose, and as the fruit was good for nothing it was removed.

TREE 41—Died in 1904 and was not replaced.

TREE 42—*Elberta Peach.* Sprayed with "Kill-O-Scale," one to water twenty parts, October 20th, 1904, and with Napthol-Sulphur at the rate of one part to water thirty-two parts, March 6th, 1905.

Started early in April, some blossoms opening on the 23d, while on the 30th it was in full bloom. Was out of bloom and in full leaf

May 11th, and continued to do well as the season advanced. A good set was made, but, as was anticipated, most of it dropped, and only six very fine fruits came to maturity in September:—all the little tree could be reasonably expected to do. Continued in full vigor throughout October, making fruit buds and holding its foliage in perfect condition. It is a little doubtful whether the tree should be allowed to remain, because it is so badly injured at base that, when it becomes heavier, it is almost certain to break off during a high wind.

June 11th, sprayed three shoots with Tak-a-nap soap, one pound in four gallons of water, to test its effect on the foliage. No injury developed.

August 22d, sprayed with arsenate of lead, one pound in nine gallons of water, to test effect on foliage and purity of insecticide. No injury developed.

As to scale, no living examples were seen until July, and only a mere trace developed during the season. As late as October 1st the tree was almost clean and received its dose of "Scalecide" October 24th, less because it was necessary than because I was spraying everything that supported the insect. On the 30th the application was duplicated with equal thoroughness, and on November 4th the leaves were all off, the tree in good condition and with plenty of fruit buds.

TREE 43—*Early Richmond Cherry.* Started early in April, buds being almost ready to open on the 12th, a few blossoms open on the 23d and everything out on the 27th. May 11th, was out of bloom, in full leaf, and had made a small set of fruit. The latter developed in due time and was mostly taken by robins.

May 25th, plant lice became apparent on the tips, and I applied soluble petroleum, one part to water thirty parts, causing no injury and wiping out most of the insects. June 11th, another lot of Aphids became obvious, more generally distributed than the earlier series, and the lower branches were sprayed with Tak-a-nap soap, one pound in four gallons of water. No injury was caused to the foliage and very little to the plant lice, which disappeared late in June.

The foliage is always thin on this tree and many of the leaves turned yellow and dropped in midsummer. Growth stopped early in July, and after an attack of slugs it looked ragged and worn. October 24th the tree was nearly bare. A few scales occurred during the summer, evidently brought on; but none of them developed and none was seen at the October examination.

TREE 44—*Elberta Peach.* Was sprayed October 19th, 1904, with "Kill-O-Scale," one to twenty, and on March 4th, 1905, with Napthol-Sulphur, one part in water thirty-two parts. This is one of the dehorned trees and was in good, vigorous condition. The tree started early, and on April 12th was a mass of swollen blossom buds, with leaf buds beginning to point out. Not until April 23d did any of the flowers open, but on the 27th the tree was in full bloom.

A very full set of fruit was apparent May 26th, and this grew well for a time until the hot, dry weather put a stop to growth and even affected the foliage so that some yellowed and dropped. After the drought broke in August, the fruit jumped and increased 100 per cent. in ten days. August 26th, about three baskets of fruit were taken off, unfit for use, because too unripe. At that time more rot than I cared to see had made its appearance and quite a percentage of the picked fruit developed the disease in a few days, before it was finally disposed of.

Up to August 19th no living scales were seen:—at that date a few full-grown examples were found, but there had been no breeding on the tree. October 1st, there was still very little scale; the foliage was beginning to turn yellow; fruit buds were making, and the tree as a whole was in fine, flourishing condition. October 24th, some foliage was off, and the rest was ready to drop: sprayed with "Scalecide," one part to twenty parts of water and covered fairly well. October 30th, sprayed again and more thoroughly, with "Scalecide," as before, and November 4th the foliage was all off.

TREE 45 is out.

TREE 46—*Japanese Chestnut.* This is the tree that has been previously recorded under No. 22. It was moved because the place in which it stood was becoming unsuitable by reason of too much shade.

Not until April 30th did the leaf buds begin to open, and matters moved along slowly until May 26th, when the tree was in full foliage and making rather weak strings of blossom buds. A check developed early in June and movement ceased. Evidently the tree started out on its reserve stock and developed until it became necessary to call upon the roots for growing material. These failed to respond properly, and the result was a standstill. Toward the end of June matters looked doubtful, but as the days advanced matters became no worse until the middle of August, when it looked decidedly sick. This was caused in part by plant lice and in part by yellow mites, which be-

came abundant on the under sides of the leaves. I feared to use insecticides, lest I turn the scale unfavorably, and up to October 24th the foliage still hung on, although thin, yellow and sickly. As there appeared now, also, some apparent shrinkage in the youngest shoots, a winter kill is not improbable.

TREE 47—*Greensboro Peach.* Sprayed with "Kill-O-Scale," one part to water twenty parts, October 15th, 1904, and with Napthol-Sulphur, one part to thirty-two parts, March 6th, 1905.

An early start was made, and on April 12th the tree was a mass of flower buds, with leaf buds just showing. No flowers opened until the 26th, but on the 30th everything was open:—a mass of showy blossoms. A heavy set appeared and this hung on until late in June, when a little dropped:—not nearly enough. Matters moved slowly early in July owing to the drought, and the fruits did not begin to ripen until the 20th. From that date until August 5th some were picked each day, good as to size, color and quality.

Throughout the season the foliage was good, and it was still intact October 24th, when fruit buds were making in good shape. August 22d, sprayed with arsenate of lead at the rate of one pound in nine gallons of water, to test effect on the foliage:—no injury developed. October 24th, sprayed with "Scalecide," one part to twenty parts of water, from the south side only.

As to scale, no living examples were seen until August 19th, when a few females, nearly adult, were found. A little increase was noted September 13th, and on October 1st there was a mere scattering in most parts of the tree. October 30th, duplicated the spray, but applied thoroughly from all sides.

TREE 48—*Black Tartarian Cherry.* Made a start early in April, but developed slowly and blossoms did not begin to open until the 21st. Was in full bloom on the 24th; petals began to fall on the 27th, and all were gone on May 7th, when the tree was in full foliage and a good set of fruit was indicated. This fruit developed normally, and when it began to color, June 2d, became a mark for the robins. By the 25th all fruit was gone, mostly to the robins, a little to the children.

Plant lice became obvious May 26th, when a number of the terminal shoots were affected. Sprayed a few of these tips with soluble petroleum, one part to thirty parts of water, getting the spray into the curled mass. Next day the insects had been killed off without ap-

parent injury to the foliage, and I sprayed others of the infested tips without making special effort to get into the curled mass—that is, I sprayed as an ordinary application would be made. On the 30th no harm had been done to the leaves, but on the other hand not much good, because the majority of the insects were protected from the spray by the curled foliage. During the early days of July the plant lice disappeared, but the unsightly tips remained, even after new growth had started above them.

August 22d, sprayed with arsenate of lead, one pound to water nine gallons, to test effect on foliage, no injury being caused.

No scale was found on the tree at any time during the season, and on October 24th it was still in full foliage.

REPORT OF THE MOSQUITO INVESTIGATION IN 1905.

REPORT OF THE MOSQUITO INVESTIGATION IN 1905.

BY JOHN B. SMITH, SC.D.

Chapter 80 of the laws of 1905 provided for a continuation of the mosquito work carried on for nearly three years, pursuant to chapter 98 of the laws of 1902, but on a somewhat different plan. The report prepared in 1904 and distributed during the early days of 1905 showed clearly enough which were the dangerous and troublesome species that it was necessary to deal with, and the methods of dealing with them were also determined. The new law, therefore, was intended to assist in the practical application of what had been learned, and an appropriation of $10,000 was made, $4,000 to become available in the fiscal year ending October 31st, 1905, and $6,000 to become available during the fiscal year ending October 31st, 1906.

This was to be used in aiding such shore communities as had the salt marsh species to deal with, not more than 25 per cent. of the amount to be paid by the State and not over $500 to go to any one municipality. The appropriation was made to the Agricultural Experiment Station, and the Director was authorized to appoint an executive officer to make such investigations and such reports as were necessary. The sum of $6,000, of which $2,500 was available in the fiscal year ending October 31st, 1906, was appropriated for the expenses of administration.

Organization was begun by the appointment of the writer as executive officer, to make the investigations and reports required by the law, and to act for the Director in all cases where the law allowed such action.

As field assistants and general investigators, Mr. H. H. Brehme, of Newark, and Mr. John A. Grossbeck, of Paterson, were appointed, and Mr. Wm. P. Seal, of Delair, was especially engaged during part

of the season in carrying on experiments looking to the introduction of the top-minnow, (*Gambusia affinis*), into the waters of New Jersey. Later in the summer Mr. Grossbeck was detailed to take charge of the office experiments in breeding and to assist in preparing the material for the necessary reports.

The character of the season was peculiar and, to a large extent, determined the nature of the work. The early spring was very dry all along shore, and there were no very high or storm tides; hence the marshes dried out rapidly; the first brood of the migrating forms was very small, and the usual second brood was reduced to a minimum. Except in a few bad places, breeding was almost at a standstill, until in late August and early September the drought was broken, the marshes became water-soaked by storm tides and frequent rains formed pools that bred out enormous numbers and flooded places that had been practically exempt earlier in the year.

In the woodland pools and large swamp areas the dry winter and spring produced a condition so unfavorable to mosquito development that not until after September did any considerable breeding take place—in fact, not even then was there anything like a normal output.

Real droughty conditions did not exist equally in all parts of the State; but after the drying out in spring the rains were never sufficiently heavy or frequent to soak the ground enough to permit the formation of pools.

The practical exemption of the shore resorts between June and late August lessened interest in the mosquito problem, and little work was done where it was most needed. Furthermore, the State law was not passed until the estimates and appropriations of the various municipalities had been made up and voted upon, so that few found themselves in a position to take advantage of the aid that was offered. The net result of the combination was that only one municipality—Elizabeth—took advantage of the State aid proposition, and only $500 was used out of the appropriation of $4,000, leaving $3,500 to be turned back into the State Treasury.

The city of Newark had expended $5,000 during the year 1904, and the board of health in that city was desirous of preventing mosquito development within the city limits, if possible, so application was made to the office for such inspections and information as might be necessary to attain that result. Mr. Brehme, was therefore

detailed to make a careful inspection of city conditions, and a copy of his report detailing breeding places located was supplied to the board. Almost or quite all of the places were abated before the end of the season.

The Essex County Park Commission was interested in the work, and, after a preliminary inspection by Mr. Brehme, the writer went over the ground with the secretary of the commission, Mr. Alonzo Church, and advised as to the line of action to be pursued. It is to the credit of the commission that every suggestion made was carefully carried out, and with the result that practically no mosquitoes were bred anywhere within the park system—which is not saying that no mosquitoes were to be found in the parks at times.

On the marshes the work done in 1904 approved itself in every particular. A very little additional ditching was found necessary; but every ditch that had not been interfered with worked perfectly, and altogether the whole marsh area except the so-called Ebeling tract was in excellent condition and not a mosquito developed on it. During the summer the board of health maintained a special inspector on the meadows, whose business it was to see that the ditches were not interfered with, and it is due to his efforts that, even on the Ebling tract, no larvæ developed until after September 1st.

Early in the season conditions on the meadow were so good that invitations were issued by the Conference Committee on Mosquitoes for a meeting to be held on the meadow during the first days of June, and a large attendance was secured, including the secretary of the State Board of Health and representatives of many neighboring localities. At that date the Elizabeth meadows had just liberated its first brood, which had extended into the city; but on the Newark meadows not a larva or pupa was to be found and only an occasional adult—a migrant from the southern territory.

Newark, at present may be considered as almost free from mosquito-breeding territory, and were the city dependent only on the local production the insect would be so rare as to be practically unnoticed. The only bad area that remains—the Ebeling tract—is to be dealt with in the near future. It is within bounds to say that not over one per cent. of all the mosquitoes found in Newark during the season of 1905 were bred within its limits.

Incidentally the elimination of Newark as a marsh breeder made it possible to make some interesting observations on the migrations of

the species, and the entrance into the city from the south of the Elizabeth brood was interestingly traced. Furthermore, the fact that Staten Island was a factor in the New Jersey problem was conclusively demonstrated by some investigations made by Mr. Brehme. Collections sent in from the Elizabeth marshes early in the season showed only *Culex cantator*, and that was also the record from the Linden and Rahway meadows. But on Staten Island *Culex sollicitans* was found to be the dominant species, and it seems certain that practically all the *sollicitans* found in early June in the Newark district of New Jersey were migrants from Staten Island. At the same time it was determined that the mosquitoes bred on the Linden and Rahway marshes followed up the valley of the Rahway and crossed the mountain range at the gap near Milburn; Morristown, Madison and the surrounding country being supplied with their mosquito troubles in great part from Linden and Rahway.

The Oranges and the immediately surrounding territory receive specimens from Elizabeth and Staten Island; quite a number of *sollicitans* coming from South Orange at a time when there were none bred in New Jersey so far as I or my agents could find.

Elizabeth, the first of all the municipalities to do satisfactory marsh work, appropriated $2,000 for the further drainage of the marsh lands within its border and received $500 of the State funds in addition. This sum was devoted to ditching work east of the Central Railroad of New Jersey, between Bound Creek and Elizabethport, under the direction of Mr. Louis J. Richards, health officer of the city, who used the True ditching machine to good advantage. Mr. Brehme made a preliminary survey of the marshes, locating the danger spots, and during the summer he made frequent, and I occasional, visits to the marshes. The conditions on these marshes are complicated by the dam carrying the New Jersey Central Railroad, which cuts the natural drainage and backs up the surface water without outlet, turning a once sound, clean meadow into a quagmire and a veritable mosquito mill.

Negotiations are in progress which will, it is hoped, result in a contribution of work or money from the railroad company to aid in restoring a satisfactory drainage scheme and in improving those natural outlets which the railroad work impaired. It is also expected that the city will make a further appropriation which, with what may be contributed from the State fund, will suffice to clean the Elizabeth

marshes before the breeding season of 1906 opens. The old work done at the mouth of the Elizabeth river has stood the test of time during the summer of 1905. It will probably require the entire season of 1906 and the expenditure of between $4,000 and $5,000 more to make Elizabeth mosquito-proof.

The marsh areas at Linden and Rahway were carefully surveyed, and it was estimated that about $5,000 would be required to clean out that territory, the bulk of the amount being needed at Linden. Efforts were made to reach the persons interested in the government and property of these municipalities; but absolutely without effect. No one seemed to care enough about the towns to consider the mosquitoes as a detriment. Yet the Linden meadows especially, are a menace to the territory lying to the north, northeast, west and northwest. It is from these marshes that the bulk of the supply gets up the valley of the Rahway and through the gap at Milburn into the Madison and Morristown regions. Their influence is therefore widespread, and so long as conditions remain as they are now, the localities just mentioned will be subject to periodical irruptions.

It may be of interest to note, in this connection that the conditions near Madison and Morristown were specifically investigated by Mr. Grossbeck, and that alone, or with Mr. Brehme, he visited the Great Piece meadows, finding them, this year, almost free from bad mosquito-breeding areas.

Irvington, Arlington and Kearny were all carefully surveyed at the request of the local boards of health, and on the whole these towns are in good condition except for that stretch of meadow belonging to Kearny, which lies south of the Pennsylvania railroad and at the junction of the Hackensack and Passaic. This corner is now in process of improvement by filling, and in another year will probably be eliminated as a mosquito breeder. During the season of 1905 an early brood of considerable extent and one very large late brood were developed, the specimens finding their way chiefly to nearby Jersey City and up the valleys of both the Hackensack and the Passaic. The marsh species were traced north into the mountains near Paterson by Mr. Grossbeck, and most of the specimens in the lowlands in both valleys were supplied from this source.

Jersey City has an easy problem to deal with, and a careful survey of the marsh land area showed that for $2,500 all the infested territory could be made safe. The local board of health was inter-

ested and took up the matter vigorously, exerting all its power to secure the necessary appropriation from common council—unfortunately without success up to the date of writing. There are no engineering difficulties whatever in the Jersey City territory, and it is a great pity that this municipality could not be induced to lend the force of its example to the surrounding, smaller places, which have small marsh areas, requiring only a few hundreds of dollars to clear.

The common belief that the low, swampy area along the Hackensack is a great mosquito-breeding place is so firmly fixed and so frequently stated that both Mr. Grossbeck and Mr. Brehme were sent in at various times and at various points during the season; returning always with the report that while mosquitoes were plentiful enough in the vegetation they were almost exclusively salt marsh forms and none was bred locally. That the Hackensack meadows abound in mosquitoes is therefore without doubt; but that they breed where they occur is not true. It is the belief that the mosquito-breeding area is practically co-extensive with the lowland swamp area, which makes most men of affairs consider the problem so great and hopeless that they simply decline to consider it at all.

I have had little difficulty in convincing members of boards of health, and especially the medical members, and a great deal has been accomplished locally under the Duffield amendment; but when the matter of securing appropriations had been brought up, the holders of the municipal purse strings refused to consider the matter seriously, or claimed that the whole thing was a State affair. Many hours of many days were spent by me in calling upon those in authority and urging action.

It has been mentioned that at times part of the New Jersey mosquito supply came from Staten Island, N. Y., and it was objected that, even if the New Jersey communities did their share, they would nevertheless be subject to attack from their political and geographical neighbor. This matter was discussed by the Conference Committee on Mosquitoes at Newark, and a committee was appointed to meet with Dr. Darlington, of the New York Board of Health, in an effort to secure the co-operation of that body to clear out at least the western shore of Staten Island. Dr. Darlington proved receptive and the matter was finally referred to Dr. Alvah H. Doty, State quarantine officer, and one of the members of the city board. After some correspondence with Dr. Doty and a trip along the shores in company with the

borough president and some residents of Staten Island, I detailed Mr. Brehme to cover the marsh area and estimate the amount needed to drain the dangerous portions. His report showed that $17,000 might be required, but would be sufficient, and an application to the New York Board of Estimate and Apportionment resulted in the appropriation of that amount. A contract was finally let for the drainage of all the mosquito-breeding marsh area on Staten Island within the amount estimated, and that work is now under way. It will be carefully watched by the office; but there is every reason to believe that before the opening of the season of 1906 Staten Island will be practically mosquito free, and will, at all events, have disappeared as a menace to New Jersey. It is believed that the work done and time spent on Staten Island resulted in a direct benefit to New Jersey.

Sheepshead Bay, L. I., and its vicinity have long suffered from mosquito attack and, partly to reclaim the salt marsh and partly to fill the breeding areas, elaborate plans of using ashes and dry refuse as collected in the city were made. Mr. Brehme and myself, alone and in company, made several visits to these dumping grounds and secured a good series of photographs showing the manner of doing the work. It is believed that in some localities similar methods may be employed and even more effectively than on Long Island. Simply to obtain information as to conditions in comparison with New Jersey, several trips were made during the summer to Astoria, Greenpoint, College Point, Flushing, etc., and some of the main sources of the Brooklyn mosquito supply were located. Most of this work was done by the writer, personally, as opportunity served during the season.

Much of the time of the office, as it thus appears, was devoted to the region containing the largest number of inhabitants and where, in the past the mosquito pest has been most seriously felt. While it has not been possible to accomplish as much as was hoped, nevertheless conditions have been materially improved, and matters will continue to become more satisfactory each year, as the feasibility of mosquito control becomes apparent.

At the request of the Board of Health of New Brunswick, formally made to the Director, the source of the mosquitoes troubling that city was located and proved to be almost entirely out of the city limits, and along the banks of the lower Raritan valley—the Amboy district. A formal report was made to the board, and copies were sent to the proper officers of the municipalities where the breeding area was sit-

uated. Unfortunately, as it turned out, several townships are involved, some disinclined to take action, others in no financial position to do so. At all events it proved impossible to get any concerted action, and there seems to be no immediate prospect of securing any.

Early in the season and at several other times during the summer Mr. Brehme went over the Shrewsbury river area and found that the work done in 1904 approved itself thoroughly, that the marshes were in excellent condition and that no mosquito breeding occurred. There is no doubt of the effectiveness of the method. Owing to the fact that the action of the tides and swells caused by passing steamers had a tendency to block the outlet ditches with sand and seaweed, it became necessary to maintain a man on each side of the river to keep the drainage system open. The work was also extended to include most or all of the area left undrained in 1904, so that this Shrewsbury area may now be said to be free from danger of mosquito-breeding. The effect of the work was noted this year for many miles around, and conditions in the entire region may be said to be greatly improved.

An effort was made to secure action by the city of Long Branch on the small marsh area within its jurisdiction; but because of some local difficulty nothing was done. The work required here is so slight that it seems a pity to allow a breeding place capable of supplying annoyance to the entire city to stand. It is a matter of less than $500 all told, and would free the balance of the marsh area between the highlands and the main shore at Long Branch.

At the request of some of the residents of Bay Head that territory was examined and reported upon by Mr. Brehme; but no action was taken upon the report. It seems probable that practical work will be taken up in this region during the season of 1906.

In response to questions from owners of pine lands which it was desired to develop, I made some investigation into the conditions existing in the Brown's Mills and Lakewood districts; finding, as I expected, that nothing that could be done locally would be of avail. The whole pine region is under the domination of the salt marsh mosquitoes. Several communities in the same territory who would have been willing to do local work were also advised that under existing conditions they were helpless.

On Absecon island conditions have been greatly improved, and within the limits of Atlantic City breeding places exist only in the northeastern section. In Ventnor most of the bad places have been

improved; but in South Atlantic there are yet enough breeding places to make it interesting. It is only a matter of a very few years before, in the normal course of improvements, all breeding places will be eliminated: it need be a matter of only one season with well-directed work.

At Ocean City much interest was manifested early in the season, and an organization to improve conditions was perfected. At the request of this organization careful surveys were made in the city limits and in this immediate neighborhood, and estimates were made of the amount of money that would be required to do the work. Unfortunately it proved here, as at other points, that there was no money available for work of this character, and the local government was simply unable to make an appropriation, because no item in the budget as passed could be drawn upon. Had the insects been as numerous as usual, it is possible that private interests might have contributed; but so long as there was no lack of custom because of mosquitoes there was no disposition to provide for a possible future infestation. The surveys and estimates have been made, however, and are available for any future work.

At Cape May the board of health and some of the persons interested in New Cape May made an effort to secure the amount necessary to improve conditions. In my report on the original investigation I showed that no place on the New Jersey shore could be more cheaply and completely rid of the mosquito pest than this point, and the board of health as a whole was in accord with the effort. As a preliminary, I sent Mr. Henry L. Viereck over the territory again, to secure definite figures of cost, and then presented the subject at a meeting of the common council. The desirability of doing the work was admitted, but again there was no fund available from which an appropriation could be made. Within the limits of Cape May City the board of health has done much to remove or abolish breeding places, and toward Sewell's Point the dredge filling by the Cape May Real Estate Company has done away with all chances of mosquito development. Unfortunately South Cape May, which has the greatest breeding area, has also the smallest population and taxable property, so, unless some combination can be effected it will be difficult to get the necessary money, even though the entire amount needed does not exceed $2,000.

Many inland communities have asked and received suggestions and advice as to the best method of dealing with local problems, and the

writer has been always at the service of individuals or bodies that desired to do practical work.

It is fair, perhaps, to refer here to the fact that, while in New Jersey the progress has not been in all respects so great as was hoped, other states have been influenced by her example, and the work done here has borne fruit elsewhere. The nearest point is New York, where the Staten Island work is of direct importance to us; but New Jersey methods have been adopted on the Pacific coast as well, some of the most desirable suburbs of San Francisco having been redeemed from the domination of a mosquito very similar in appearance and habits to one of our eastern marsh species.

All the conclusions reached in the report of 1904 have been confirmed by those that have investigated the subject, and in most of the Southern States active campaigns are now in progress or in contemplation.

There is practically no expressed doubt among medical men of the importance of mosquitoes in the transmission of disease, and the recent fight against yellow fever in New Orleans was conducted exclusively on the basis of such agency. So the exercise of the quarantine regulations at the port of New York is laid upon the same foundation. While not all mosquitoes are known to be direct transmitters of disease, there are none that are desirable or in any way useful, and there is absolutely no reason why, in New Jersey, we should continue to suffer from them, except the feeling that it will cost too much.

To answer this point, Mr. Brehme, whose experience in marsh work fits him most excellently for that purpose, was instructed to make a complete superficial survey of the salt marsh area from Jersey City to Cape May, and from the Cape along the bay shore and Delaware river, estimating the cost of drainage or filling at all points.

Lest it should seem as if such an estimate were mere guess work, it should be noted that for the thirty miles of marsh area on Staten Island, Mr. Brehme's estimate was slightly over what a responsible contractor agreed to do it for, and that his estimates on the Newark and Elizabeth marshes were always well within the limit for which good work was accomplished. I have little doubt that the amounts here given will be sufficient in most cases, and if in any case local conditions cause an increase, it would be balanced by the liberal estimates on the general work. It should also be noted that there is

not one grand estimate for the whole work; that might be readily considered a guess; but an estimate for section after section, which can be easily verified by any one familiar with such work.

In detail the estimates—some of them from earlier surveys—are as follows:

The Jersey City marshes	$2,500 00
The Bayonne meadow	500 00
The meadow bounded by Elizabeth on the north, Carteret on the south, Arthur Kill on the east, Linden township on the west; soil good for hand-ditching	4,500 00
The Elizabeth marshes are omitted as under process of cleaning, and the Kearny triangle is also treated as of no further importance.	
The meadow bounded by Carteret on the north, Perth Amboy on the south, Arthur Kill on the east and Woodbridge on the west; including Port Reading, Sewaren, Maurer, North Perth Amboy and Woodbridge to Port Reading R. R.	4,500 00
The soil is good east of the N. Y. & L. B. R. R., but on the west contains more clay: it will all have to be hand-ditched.	
The Raritan flats, extending on both sides of the river, from its mouth to the end of the salt marsh	5,000 00
The meadow bounded on the north by South Amboy, on the west by N. Y. & L. B. R. R., on the south by Morgan Station and on the east by Raritan bay, can be drained for	50 00
The area bounded by Morgan Station on the north, Lawrence Harbor on the south, Raritan bay on the east and Jacksonville on the west, will cost	2,500 00
The soil on this meadow is good and there are good creeks to drain into.	
The marsh bounded by Lawrence Harbor on the north, Cliffwood on the south, Raritan bay on the east, N. Y. & L. B. R. R. on the west.	1,000 00
Soil good for hand-ditching.	
The stretch bounded by Matawan on the west, Keyport on the east and Raritan bay on the north, can be ditched by hand and a perfect result obtained for	1,500 00
The meadow bounded by East Keyport on the west, the power-house of the Central Trolley Company on the east, Raritan bay on the north and Hazlet on the south, will cost not over	800 00
Soil and general conditions good.	
The territory between the Central Jersey Trolley Company's power-house on the west, Lorillard on the east and Raritan bay on the north—soil mixed with clay—will cost	700 00
The area bounded by Lorillard on the west, Keansburg on the east and Raritan bay on the north	600 00
The meadow bounded by Keansburg on the west, Port Monmouth on the east and Raritan bay on the north; soil good for hand-work,	800 00
The marsh bounded by Port Monmouth on the west, Belford on the east and Raritan bay on the north, will cost	500 00

The area bounded by Belford on the west, Atlantic Highlands on the east, Raritan bay on the north.......................... $800 00

The soil near Belford is good for draining; near Atlantic Highlands is gravel and will require filling.

The area bounded by Water Witch on the north, Highlands of Navesink on the south, Raritan bay on the east, Central R. R. on the west; good ditching.................................. 200 00

The Sandy Hook Reservation is omitted from consideration: it belongs to the United States Government, the commandants in charge have been notified of the location of the breeding areas, and the whole territory can be cleaned without much expense by Post labor.

Most of the Shrewsbury area has been cleaned by private subscription, but a little work is yet needed.

The meadow bounded by Pleasure bay on the east, Little Silver creek on the west, the Shrewsbury river on the north and Eatontown on the south—good ditching; not above.................... 700 00

The meadow between Pleasure Bay bridge on the north, Long Branch on the south, North Long Branch on the east and Pleasure bay on the west; good drainage............................. 100 00

At this point the mainland reaches the shore and for several miles there is almost no salt marsh except in the Shark river section, and that is not a dangerous breeder. Such places as occur between Bradley Beach and Belmar can be cleaned up for about 200 00

Salt marsh begins again near Sea Girt, and the territory from that point south to Point Pleasant and between the ocean and the N. Y. & L. B. R. R., will cost............................ 1,000 00

Some places can be ditched, but others must be filled: it includes Manasquan and Brielle.

The meadow bounded by Point Pleasant on the north, Metedeconk river on the south, Atlantic ocean on the east, including Bay Head; ditching in some parts, but mostly sand-filling, will cost.. 500 00

The area between Barnegat bay and the ocean, from Bay Head to Mantoloking, is partly marsh and partly depressions; a little draining is possible, but most is grading and filling, for which plenty of material is at hand............................. 1,000 00

The marsh and depressions between Barnegat bay and the ocean, from Mantoloking to Chadwicks: mostly grading and filling.. 1,500 00

The stretch between Chadwicks and Lavallette, and ocean and bay, marsh and depressed area, mostly sand that will not stand ditching 500 00

Between Lavallette and Berkeley, ocean and bay, territory as before, and mostly to be filled, not over......................... 2,000 00

Between Berkeley and Life-saving Station No. 14, ocean and bay, including Seaside Park; more filling than ditching........... 1,500 00

On the main shore, beginning at the head of the bay, from the Metedeconk river on the north to Kettle creek on the south, and from the bay to Metedeconk neck, the soil is good for ditching and little filling is needed; the cost will be.......... 4,500 00

From Kettle creek on the north to Mosquito cove on the south, and from the bay west to Silverton, the meadow is susceptible to ditch drainage and little filling is needed; the cost will be..... 2,000 00

From Mosquito cove on the north to Toms river on the south, and from the bay to Island Heights, ditching is possible and will cost......	$8,000 00
The marsh area bounded by Toms river on the north, Cedar creek on the south, Bayville on the west and Barnegat bay on the east; soil good for hand or machine ditching......	8,000 00
The marsh area bounded by Cedar creek on the north, Forked River (town) on the south, Forked river on the west and Barnegat bay on the east; soil good for hand or machine ditching; cost to drain	8,500 00
The meadow from Forked River on the north to Waretown on the south, along the bay shore; soil good for hand or machine ditching	5,000 00
The meadow from Waretown on the north to Barnegat on the south, along Barnegat bay; soil good for hand or machine ditching..	6,000 00
The point or spit of land from Life-saving Station No. 14 to Barnegat inlet, between ocean and bay; mostly grading and filling...	4,000 00
The meadow on main shore between Barnegat on the north, the Penna. R. R. bridge on the south, Manahawkin on the west and the bay on the east; soil excellent for ditching; cost, including all the islands......	18,000 00
The meadow and depressions on Long beach, between ocean and bay, from the point at the inlet, south to Life-saving Station No. 20; mostly sand filling......	4,500 00
The stretch on the mainland between Manakawkin on the north, West creek on the south and Little Egg Harbor bay on the east; the soil good for either hand or machine ditching......	10,000 00
The area bounded by West creek on the north, Tuckerton creek on the south and Little Egg Harbor bay on the east; soil is all right in every respect for hand and machine ditching....	8,000 00
The meadow bounded by Tuckerton creek on the north, Bass river on the south, Great bay on the east; one of the worst stretches in the State, but with ground good for either hand or machine ditching	16,000 00
The Bass river marsh, beginning at the mouth and extending to the highland	2,000 00
Between ocean and bay, from Life-saving Station No. 20 to New inlet, including what is yet to be done at Beach Haven; mostly filling	6,000 00
On the mainland along the Mullica river, bounded by Bass river on the east and Lower Bank on the west, including both shores: soil is good, several ditches have just been cut by the hay men, and the soil seems to be just the very best for both hand and machine ditching	10,000 00
The meadow bounded by Nacote creek on the north, Somers' cove on the west, Great bay on the east and Little bay on the south; good ditching	15,000 00
Island beach, marsh and depressed areas; mostly sand; must be leveled; little ditching possible......	1,000 00
The islands between Great bay on the north, Brigantine channel on the south, Island beach on the east and Little bay on the west,	2,000 00
The meadow bounded by Somers' cove on the north, Absecon on the south, Red and Absecon bays on the east; soil good for ditching	4,000 00

The meadow bounded by Absecon on the west, Great Thorofare on the east and the Pennsylvania railroad on the south....... $1,000 00

This place is not bad and it is perhaps a question whether mosquitoes breed here at all, except under unusual conditions, but the sum above mentioned will remove all possible danger spots.

The territory bounded by Pleasantville on the north, Somers' Point on the south, Risley's channel on the east and great Egg Harbor bay on the southeast; soil good for ditching............ 12,000 00

The meadow bounded by Somers' Point on the south, May's Landing on the north and Great Egg Harbor river on the west; part ditching, part filling 5,000 00

The area bounded by Tuckahoe creek on the south, May's Landing on the north and Great Egg Harbor river on the east; ditching, filling 10,000 00

Brigantine beach, meadow and depressions, mostly filling, for which there is plenty of material at hand; should not under any circumstances cost more than.............................. 3,000 00

Absecon island, from the inlet at Atlantic City to the inlet at Longport, west to Lakes bay; soil good in some places, filling necessary in others.................................... 6,000 00

Ocean City, from the inlet to Fifty-seventh street, meadow and low depressions; mostly filling.............................. 2,500 00

The meadow bounded by Beasley's Point on the east, Tuckahoe creek on the north, Petersburg on the south, Tuckahoe on the west; soil good for ditching................................... 6,000 00

Peck's beach, from Fifty-seventh street to Corson's inlet; meadow bounded by Beasley's Point on the north and Ocean View on south; mostly filling................................... 8,000 00

Meadow and depressions from Corson's inlet to Townsend inlet on the south, Seaville on the west; mostly sand, and filling will be mostly required.................................... 5,000 00

Meadow and depressions from Townsend inlet to Hereford inlet, and from Townsend inlet on the west to Great sound on the south; soil good in some parts; sand in others; ditching and filling 8,000 00

The marsh area bounded by Great sound on the north, Great channel on the east, Pennsylvania railroad to Holly Beach on the south, Cape May Court House on the west.................. 4,000 00

Five Mile beach, for its full length to the Thorofare on the west, can be entirely cleaned up for........................... 2,500 00

A good portion of the five-mile tract at Wildwood and Holly Beach has been recently filled in by the dredge and this work is being continued.

The meadow bounded by the Pennsylvania railroad on the north, the county road on the south, Rio Grande on the west, Richards and Grassy sound on the east, will not cost above........... 3,000 00

The meadow between the county road on the north, Cape May City on the south, the highland on the west and the bays and sound on the east, will cost.................................. 5,000 00

Two Mile beach, meadow and depressions, mostly filling, can be made safe for 1,500 00

At Cape May the meadows and depressions from the city to the point, can be cleaned up for	$600 00
This does not include clearing the cape marsh, which requires one or more tide gates and may require some ditching; the whole at a cost not to exceed	1,500 00
This would include the meadow at Life-saving Station No. 41. An enormous amount of filling has been done between Sewell's Point and Cape May City, and the whole of that territory is now mosquito safe.	
The area between Port Norris and Dennis creek, along the shores of Delaware bay; mostly good ditching, can be drained for	8,000 00
Between Dennis creek and Higbee's Landing, along the west shore of Cape May peninsula, are several detached marshes which may cost	10,000 00
Between Port Norris, along the shores of the Maurice river, west along the bay to the Cohansey, and along the Cohansey to Bridgeton, drainage would cost	20,000 00
Between Salem creek and the mouth of Cohansey creek is a stretch of meadow about twenty miles in length and from 500 feet to three miles in width, most of which is perfectly safe, and all of it easily drainable; it will cost not over	15,000 00
	$315,550 00

It appears, then, that for the sum of $325,000, at the outside, the entire shore line on salt water in the State of New Jersey could be made mosquito safe:—$10,000 being added for expenses of administration and supervision. From three to five years would be required to do the work, depending upon the amounts of money that would be available; but it should take three years for proper supervision.

As to the result, all the shore resorts would be free from the clouds of mosquitoes that now infest them for the entire season. The entire pine region, which is now so overrun most of the summer as to be almost uninhabitable, would be freed of its most offensive species. The cities on New York, Newark and Raritan bays would be practically mosquito free, and the first range of the Orange mountains almost entirely so. The influence of the work would extend not only to the immediate vicinity of the shore, but for many miles inland. New Brunswick, for instance, which has no salt marsh, would be made almost entirely free.

Would there not remain many large inland mosquito-breeding areas? Undoubtedly: in the early spring woodland pools would breed great quantities; but they never leave the woods and disappear in June, not to occur again that year. Some of the low, wooded sections of the Great Piece meadow would breed mosquitoes all the summer through;

but these also are species that have a limited range of flight and are rarely found outside the limit of their breeding area:—most of the species have never been found in cities or towns.

There would also remain what may be called the dirty-water mosquitoes:—the species of *Anopheles* and the common rain barrel or house mosquitoes. These offer a problem eminently within the control of local authorities and out of the domain of State interference. They breed in sewer catch basins, puddles, cisterns, rain barrels and in every body of stagnant water no matter how small; but they usually remain pretty close to where they are born, and any active board of health inspector can secure the elimination of 90 per cent. of all the more obvious breeding places in his jurisdiction in a very short time. Complete freedom from the pests will not be secured until every person is educated to recognize the larvæ and the dangers of dirty water; but comfort in streets and parks and in clean sections of the cities can be obtained by the elimination of the salt marsh species.

As to benefits to be derived aside from the comfort of living; the increase in value of shore and suburban property would justify the expenditure over and over again. On Barnegat bay alone millions could be safely invested, while in the suburbs of Newark and along the Orange mountains, property would be available for building sites which is now of little or no value because the swarms of mosquitoes in summer make it impossible to enjoy the natural beauty of the location.

The scientific work of the survey has been continued, but the character of the season was so unfavorable that some of the problems could not be worked out, simply because there were no breeding pools. Mr. Grossbeck was in general charge of the records and the following notes have been prepared by him, though I have added notes and conclusions not in Mr. Grossbeck's records:

NOTES OF THE SEASON.

During the summer of 1905 little was accomplished in the way of collecting and studying species other than those which were of economic importance, and these only to determine when broods would issue, making it possible to supply information to municipalities that would be directly affected.

Some collecting, however, was done, and two species heretofore unrecorded from New Jersey and two others new to science were secured.

In the report made in 1904 thirty-seven species of mosquitoes were described, all but one, *Culex perturbans*, in both the larval and adult stages. Of these, thirty-six species had actually been taken in the State; the remaining one, *Culex atropalpus*, was believed to occur with us since we are situated intermediate to the States from which it is recorded. At present writing forty-one species are known to occur, and if the prediction that *Culex atropalpus* will be found proves to be correct, forty-two will be credited to New Jersey.

On the pages following only such forms as are new are described, and notes to the species described in the former report are added.

Anopheles punctipennis Say. (The Mottled-Wing *Anopheles*).—This species has been taken in its usual numbers, but nothing was added to our knowledge of its life history.

Anopheles maculipennis Meig. (The Four-Spotted *Anopheles*).—No specimens of this species were taken in the larval stage, but Mr. J. Turner Brakeley sent in an adult female from Lahaway, where it occurs rarely.

Anopheles crucians Wied. (The Day-Light *Anopheles*).—No specimens of this mosquito were collected during the summer in any stage, the drought along shore apparently preventing its occurrence. In early November Mr. Brehme sent in a few larvæ and pupæ taken in pools on the Elizabeth marshes in company with *Culex cantator* and *C. salinarius*. Adults emerged from the pupæ November 4th and gave both the latest record for it and the northernmost locality thus far discovered.

Anopheles barberi Coq. (The Tree-Hole *Anopheles*).—This mosquito had not been taken in New Jersey until the present year, and is the smallest of the four species of *Anopheles* occurring with us. It is brownish, with unbanded beak and dark brown, unbanded legs. The wings are entirely without spots and this character serves to distinguish it from all other New Jersey forms.

Description of the Adult.

Female (Figure 1).—The length is about 3.5 mm., = .14 of an inch, exclusive of the proboscis. The head is brown, eyes meeting on top, occiput brown, with scales of a yellowish color near the neck; the proboscis is half the length of the body and covered with scales of a

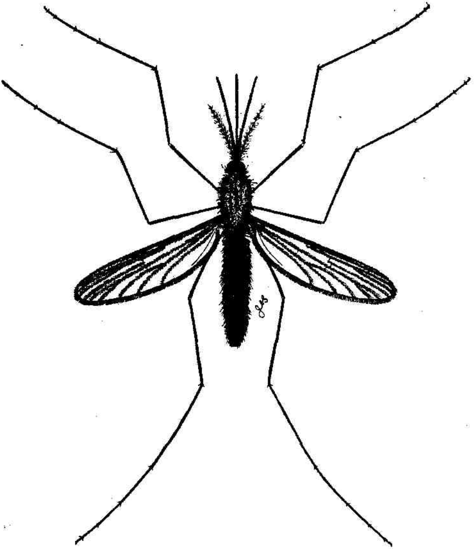


Fig. 1.
Anopheles barberi **Coq : female adult; enlarged. Original.**

pale brown color; the antennæ are pilose, brown, with a few whitish scales scattered over the surface, save the basal joint, which is yellowish; the palpi are brown, long and slender, four-jointed, the terminal joint with a few white hairs at the apex; the dorsum of

the thorax is grayish-brown, smooth and without scales; three brown stripes set with black bristles extend from the anterior margin to the middle, and the sides are also brown and well clothed with black bristles, as is the posterior part of the dorsum. The legs are long and slender, dark brown, almost black, with steely-blue reflections; the femora are somewhat paler beneath and there is a small, faint, yel-

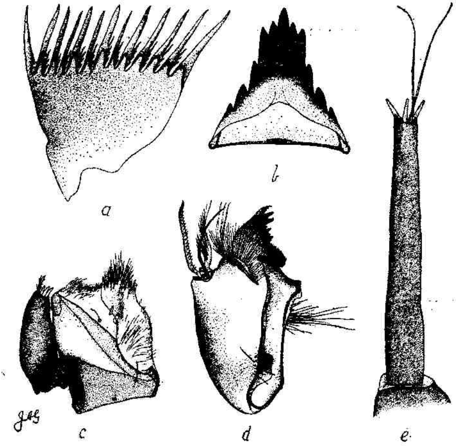


Fig. 2.
Anopheles barberi: details of larval structure: *a*, one of the scales; *b*, mentum; *c*, maxilla; *d*, mandible; *e*, antenna; all much enlarged. Original.

lowish dot at the knee. The claws are simple on all feet. The wings are hyaline, with brown scales attached with uniform thickness to the veins and margins. The abdomen is brown, in some specimens paler at the base of the segments, and fine brownish hairs are scattered evenly over the entire surface; beneath it is evenly grayish-yellow.

Male.—Differs from the female in the antennæ being plumose and the terminal joint of the palpus swollen and wholly brown, not tipped with white. The claws of the anterior tarsal joint are unequal in size,

the large claw with a median prong and a small, tooth-like process at its base, the small claw very short and simple. The claws of the mid and posterior tarsal joints are equal and simple, the latter somewhat smaller than the median.

Description of the Larva.

The larva in general appearance resembles the other species of the genus which occur in New Jersey, but is easily separated from all by the very dark head; it is further separable from *punctipennis* and *maculipennis* by the anal gills, which are even shorter than in *crucians*.

The full-grown larva measures 6 mm., or .24 of an inch in length. The head is dark brown with a single black diffused spot in the center of the vertex and a pale yellow circle around the eyes. The antennæ (Figure 2 *e*) is two-jointed, the first joint broader than long and fixed immovably; the second is much longer and narrower, almost straight, tapering toward the apex, terminated by three pegs of uniform length and two long, simple, flexible bristles; in color it is evenly dark brown with the apical articulations pale yellow. Apparently, there is no tuft or divided hair on the shaft of this second joint and no tubercle or pit in indication of one. The mentum (Figure 2 *b*) is triangular in form, almost as broad as long, with an apical tooth and five others on each side. The mandible (Figure 2 *d*) is elongate. with three large and several small teeth and a comb-like structure at the apex; on the dorsal surface is one long, slender, simple spine, a stouter one with short bristles, and a large, weakly-chitinized, compound spinet. The maxilla (Figure 2 *c*) is a pale yellow, squarish structure, with a thick tuft of short hairs at the apex and patches of hair irregularly distributed over the surface; its palpus is dark brown, almost three times as long as its greatest width, with three yellow, apical pegs and a small tuft of two or three branched hairs arising from a pit near the apex. The triangular plates, one on each side of the respiratory apparatus on the eighth segment, each bear thirteen or fourteen long teeth of almost even length on the posterior margin, and each tooth has three or four minor teeth at the base. The tracheal gills are slightly inflated, pointed and about one-fourth the length of the ninth segment.

Habits.

This species, like *Culex triseriatus,* is confined to the water contained in tree-holes. It was described from Plumber's Island, Md. Mr. Dickerson found a few larvæ associated with those of *C. triseriatus* and *C. signifer* in a tree-hole at Chester, Morris county, September 6th. The same day a male *A. barberi* emerged from a pupa, with specimens of its associates. On the 8th, one female emerged and on the 11th,—another, the last in the lot, though *triseriatus* and *signifer* hatched in large numbers. Another visit to the tree was made September 9th, but no larvæ were found and only a single male hatched September 10th, from a collected pupa.

The larvæ rarely descend to the bottom, but like their allies maintain a horizontal position on the surface of the water. This would suggest a diet of floating particles of vegetable matter; but Dr. Dyar says that they are predaceous and the mandibles seem to bear out this statement. He also says that the winter is passed in the larval stage, a point which we have been unable to verify and which is not in accord with the habits of the other species of this genus occurring in the State.

Psorophora ciliata Fabr. (The Fringe-Legged Mosquito).—This mosquito has been rare throughout the season, though Mr. Brehme took a number of the larvæ near Newark in the middle of June, the first adults emerging on the 26th of that month.

Janthinosoma musica Say. (The Big Wood Mosquito).—This species was not taken in any stages, its breeding places in the Great Piece meadow having dried out completely.

Culex jamaicensis Theob. (The Spotted-Legged Mosquito).—This mosquito was taken commonly in the larval stage, breeding in the lot pools at New Brunswick; but curiously enough the adults seemed not to be troublesome at the nearby dwellings.

Culex discolor Coq. (The Mottled Mosquito).—Mr. Seal collected full-grown larvæ and pupæ of this species at Delair, Camden county, in company with *C. pipiens,* August 15th,—the latest record of the occurrence of larvæ thus far in hand. The larvæ were attacked by a fungus and placed in alcohol. Adults emerged from pupæ on the three days following the 16th. August 8th was the latest previous record for adults.

Mr. Seal writes that he found larvæ in two temporary pools at Delair, where, like *Psorophora,* they occur only when certain con-

ditions prevail. These two holes usually become stocked with *Sayomyia albipes* larvæ shortly after it rains, and it is only after these disappear that *discolor* can be found. It appears from this that the *discolor* fall prey to the predaceous *Sayomyia.*

Culex sollicitans Walk. (The White-Banded Salt Marsh Mosquito). —This species did not begin to breed on the salt marshes of the Newark and Raritan bay districts until well along in summer. On Staten Island, just across the Kill, they swarmed, while on the New Jersey meadow not one developed. This peculiar development made it possible to determine definitely, not only that the species came over from Staten Island; but that it extended along the valley of the Rahway and across the first range of the Watchung mountains. It was not until after midsummer that this species became at all common, and it remained, north of the Raritan bay, less abundant than *C. cantator.* At Barnegat bay and southward, conditions were reversed and *sollicitans* were plentiful—offensively so in early September.

Culex perturbans Walk. (The Irritating Mosquito).—The larva of this mosquito still remains undiscovered, though adults have been as common at Lahaway as previously recorded. Some interesting observations, however, were made by Dr. Dyar in the United States and by Dr. Goeldi on a closely allied species in Brazil. The results have been similar, and show that the species must breed naturally under some extremely peculiar conditions, as in neither case were larvæ obtained from eggs brought beyond the first stage of development.

Dr. Dyar secured from captured females eggs which were laid in boat-shaped masses of about 150 each, similar to those of *Culex pipiens.* The young larvæ have very long antennæ, with a single hair representing the tuft at the basal third. The comb of the eighth segment is a single row of short, pointed spines. The anal siphon is constricted at the outer third, the terminal portion linear, and ending in a bunch of stout, recurved hooks, the basal portion is slightly constricted centrally, bearing a long hair on each side, but no pecten.

Concerning their habits, Dr. Dyar says: "The larvæ refused to feed. They did not use the mouth brushes perceptibly, but lay at the bottom of the water absolutely motionless for hours and days together. Some specimens we thought dead; but on transferring them to a slide, they wriggled in a fairly lively manner, pushing the curiously shaped air tube as if to fasten it to some object."

Mr. Brakeley sent in a male from Lahaway, June 4th, the first captured there, and the belief that the species is a migrant therefore

seems less likely. Mr. Brakeley's latest capture in 1905 was September 12th, seventeen days later than any previous record. All sorts of possible breeding places were investigated by Mr. Brehme and some by Mr. Grossbeck, in several parts of the State; but no larvæ were secured.

Culex tæniorhynchus Wied. (The Small, Salt Marsh Mosquito).—This was very rare throughout the season. A single female specimen was sent in from Lahaway, and this is not only the farthest point inland where it has been taken; but the first time it was taken there at all.

Culex sylvicola Grossb.* (The Scaly-Winged Mosquito).—Larvæ were found in some numbers in swampy woods near New Brunswick, where they were taken the year before. They were rare as compared with their associate, *Culex canadensis*, the ratio being about one *sylvicola* to 1,000 *canadensis*. April 10th ten larvæ and four pupæ were secured, and on May 2d two larvæ and thirty pupæ, showing that the larvæ pupate almost simultaneously. Most of the larvæ were placed in alcohol and from the pupæ adults emerged as follows: Twelve males and one female May 4th, two males and twelve females May 5th, two males and six females May 6th and one male and one female May 7th.

As previously noted there is apparently only a single spring brood. No later collections turned up additional material, and adult captures were more and more worn as the season advanced.

Culex cantator Coq. (The Brown, Salt Marsh Mosquito).—The early broods on the New Jersey salt marshes north of the Raritan bay were of this species, almost exclusively, and, while the brood on the Newark marshes was entirely absent and on the Elizabeth marshes not very heavy, the Linden area sent two very respectable swarms a considerable distance inland. At New Brunswick this was the dominant species throughout the season, though the spring migrations were small and even the September swarms not very heavy. All the previous observations were confirmed.

Culex cantans Meig. (The Brown Woods Mosquito).—It is strange that where this species bred in great numbers in Newark a few years ago, it should be entirely absent in 1905; and that in the Great Piece meadows, twelve or more miles distant, which had been thoroughly explored previously without finding the species, it should occur commonly. Not a larva was found in Newark, in the pools where it was

* This is the species erroneously identified as the Pacific coast *squamiger* in

known to breed in 1904. In the Great Piece meadows large larvæ occurred April 17th, in many pools, some of which were two miles distant from each other. They were very local, large numbers being found in one pool, while others directly adjacent and of precisely the same character, did not contain a single specimen.

In one locality they were associated with larvæ of *C. canadensis*, *C. abfitchii* and *Corethra cinctipes*, about one third being *cantans;* in another they occurred with *C. pretans*, *C. aurifer*, *C. canadensis* and *Aedes fuscus*, only a very small proportion being *cantans*. Adults began to emerge April 26th and continued to issue till May 8th. There is no record to show that there is more than one brood.

Culex abfitchii Felt & Young. (=*siphonalis* Gross.) (The Brown-Striped Woods Mosquito).—Nine half-grown larvæ were taken April 17th, in the Great Peace meadows, in company with *C. canadensis*, *C. cantans* and *Corethra cinctipes*. Another collection, made April 25th, turned out fifty additional larvæ, and on this same day the first pupa appeared. On the whole the larvæ did not do well and only a small proportion reached the adult stage; the first, a male, emerging May 3d; the last, a female, May 12th.

Culex sylvestris Theob. (The Swamp Mosquito).—This mosquito was sent in from many localities and in all stages from young larvæ to adults. It has held its own in numbers as compared with previous years. The earliest larvae were found April 14th, when they occurred in comparatively small numbers associated with *C. canadensis* and *Aedes fuscus*. The first adults from this lot began to emerge April 26th and continued to issue until April 30th, when the culture was closed.

Culex signifer Coq. (The White-Lined Mosquito).—This species has been sent in from three localities, all of them September collections, and as, in one of the localities, earlier collections had been made in the same situations, the question arose as to whether or not the species bred only in fall.

Mr. H. O. Marsh, of Chester, and Mr. Dickerson jointly tested this point and the results indicate, rather conclusively, a single fall brood. Mr. Marsh found full-grown larvæ and pupæ September 5th, 1904, in a hollow tree, associated with those of *C. triseriatus*, and October 3d of the same year, a single, fully-developed larva was taken; apparently a belated example. In 1905 he visited the tree again, May 21st, and though *triseriatus* larvæ in various stages were found,

no *signifer* were present. June 25th and July 22d, periods of one month apart, other visits were made, but no larvæ other than *triseriatus* were taken.

It may be mentioned that the pool in this tree hole never dries up, no matter how long the drought. It is frequently twelve inches in depth and has never yet been observed with less than six inches of water.

Mr. Marsh was absent from Chester later in the season, so Mr. Dickerson continued the observations. He visited the tree September 6th and found full-grown larvæ and pupæ of *signifier* in company with *triseriatus* as usual, and *Anopheles barberi*. Several adult *signifer* were also seen resting on the sides of the tree hole. From the pupæ thirty-five adults issued during the seven days following; all but the three first emerging were females, the males having already hatched.

Culex atropalpus Coq. (The Rock Pool Mosquito).—No effort has been made to find this species along the rocky banks of the Delaware river in Warren county, where it is supposed to breed; so it still remains as only a probable inhabitant of the State.

Culex canadensis Theob. (The Woodland Pool Mosquito).—The earliest adults hatched April 22d, from pupæ collected at Newark, April 8th, and the latest adults emerged September 11th. Larvæ were found at Arlington, April 14th, in company with *Anopheles punctipennis*, *C. territans* and *C. sylvestris*. It has never before been found by us in pools with the first named species.

Culex niveitarsis Coq. (The Snowy Foot Mosquito).—This species, which is known only by the types, was searched for in its habitat in rocky pools at Paterson, but no specimens in any stage were secured. It is apparently very rare, since it has not as yet been found by any of the other collectors in the United States.

Culex pallidohirta Grossb. (The Pale-Haired Mosquito).—A light-colored, medium-sized mosquito, with cream-colored, unbanded legs, brownish, unbanded beak, and silvery gray, unbanded abdomen. The wings are unspotted and the thorax is pale brown, marked with darker scales on the sides of a narrow median groove, and inclosed in a semicircular lateral line on the posterior half. The latter character can be seen only in bred specimens.

Description of the Adult.

Female (Figure 3).—Measures 4.5—5 mm.,=.18—.20 of an inch in length, excluding the proboscis, which is about half the length of the body. The occiput is clothed with yellowish scales and a few dark brown ones intermixed; the antennæ are brown, the basal joint

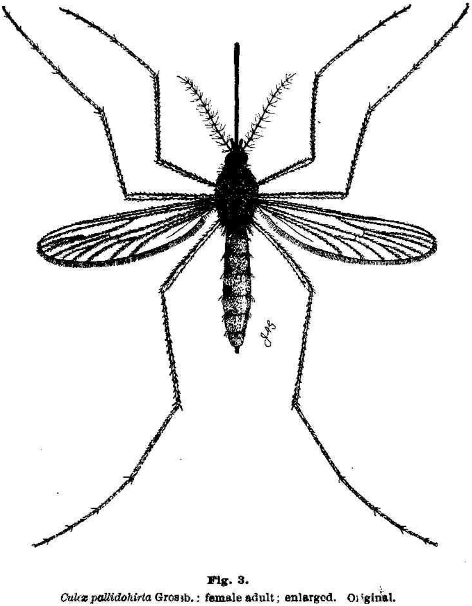


Fig. 3.
Culex pallidohirta Grossb.: female adult; enlarged. Original.

and basal half of following one dirty yellow; the proboscis is brown with whitish scales scattered over the surface, save at the apical fourth; the palpi are four-jointed, brown, tipped with silvery-white, the apical joint minute, flattened and slightly spiny. The dorsum of

the thorax is covered with pale brown scales and has a narrow median furrow, obsolete on posterior portion, bounded on each side by scales of a slightly darker color: a lateral line of pale yellow scales beginning near the posterior margin and extending to the middle of the lateral margin, also encloses these darked scales. The pleura are yellowish-brown, with patches of whitish scales. The legs are cream colored, the anterior part of all femora and also anterior part of tibia of fore-leg brownish; the apical two or three joints of fore and mid tarsi are also brownish. The claws are equal in size on all feet, *each with a single tooth at the middle.* The abdomen is unbanded, creamy, with metallic, silvery-gray lustre in living specimens, but darker with grayish shadings when pinned; the *genitalia* are dark brown.

Habits.

This species was taken only in the pupal stage with *C. canadensis* larvæ and pupæ and *Corethra cinctipes*, collected by Mr. Brehme in the Orange mountains, May 19th and May 22d. From the first lot a female emerged May 25th, and out of the second another female issued on the 26th. All remaining larvæ were put into alcohol at once, and though numbering hundreds, none could be differentiated from *C. canadensis*. Another collection was made May 27th, and its entire mosquito contents taken; but all larvæ proved to be *canadensis*, and none other than that species hatched from the pupæ. It is probably one of the early spring forms with but a single brood, since it was not taken in any of the collections later in the season.

Culex triseriatus Coq. (The Tree-Hole Mosquito).—This mosquito was taken continuously throughout the season wherever tree-holes containing water were found. The earliest record of larvæ thus far is April 18th, when examples in the first and second stages of development were found on Garret mountain, Paterson.

Culex serratus Theob. (The Silver-Striped Mosquito).—This species was not taken in any stage.

Culex punctor Kirby. (The Unbanded-Legged Woods Mosquito). —This is a rather large mosquito with brown, unbanded legs and beak. The thorax is evenly clothed with golden brown hair and the abdomen is broadly banded with white at the base of the segments. In calling this species *punctor* we are following Dr. Dyar, who says that *abserratus* F. & Y. is a synonym. Dr. Felt does not admit this, and the description given by Theobald does not cover this species. At all events the form here called *punctor* is the form described as *abserratus*, —so Dr. Felt says.

Description of the Adult.

Female (Figure 4).—Large, rather robust, averaging 5—5.5 mm., = .20—.22 of an inch in length, exclusive of the proboscis. The occiput is clothed with golden brown and some yellowish scales on top, whitish scales on the sides; the antennæ are brown, with the basal

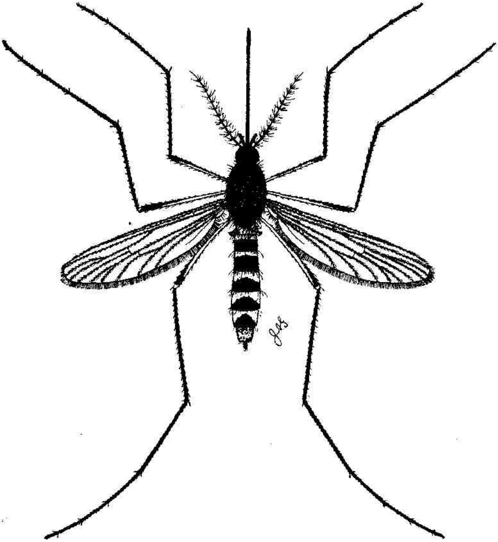


Fig. 4.
Culex punctor Kirby: female adult; enlarged. Original.

segment yellowish; the proboscis is perceptibly longer than half the length of the body; the palpi are wholly brown, four-jointed, with apical joint minute, rounded and spiny. The thorax is evenly clothed with golden brown scales; there is a very narrow median groove and

a lateral, semicircular one on the posterior half; but this is seen only in very fresh specimens. The pleura are almost wholly covered with white scales. The femora are cream colored, becoming brown toward the apex on the upper surface, then with a sharply defined creamy spot at the knee; the tibia and tarsi are uniformly dark brown, save that the former has yellowish bristles. The claws are equal in size on all feet, each claw with a single median tooth. The abdomen is very dark brown, with broad, clean-cut white bands at the base of the segments, which become wide laterally; beneath it is whitish with intermixed brown scales and a narrow, median brown stripe.

Male.—The male is like the female in general appearance. The antennæ are brown with paler plumes, and the palpi are brown without rings or marks. The claws of the anterior and mid tarsal joints are unequal in size, the larger with a single median tooth, the smaller with a single tooth near the base. The posterior claws are equal, each with a single tooth near the middle as in the female.

Description of the Larva.

Dr. Dyar differentiates the larva from *C. sollicitans* (Proc. Ent. Soc. Wash., vol. VI., p. 39), and figures it with some of the details (Jour. N. Y. Ent. Soc., vol. XII.), but here gives no description. His figures agree with those given subsequently by Dr. Felt (Bull. 79, N. Y. Sta. Mus.) under the name *Culex abserratus*, which is a synonym of what Dr. Dyar calls *C. punctor.*

As Dr. Felt says, the larva bears a general resemblance to *C. serratus.* The antennæ are rather stout, with the tuft at the basal third. The mentum is rather broadly triangular, bearing twenty-seven fine triangular teeth. The comb or scale patch on the sides of the eighth abdominal segment consists of six or seven scales arranged in a curve. The anal siphon is about three times as long as wide, with a double posterior pecten or row of spines, each row consisting of twelve to fifteen closely set spines. The anal gills are long, slender and uniformly tapered.

Habits.

From a lot of larvæ and pupæ collected in the woodland near New Brunswick, April 28th, a male and four females emerged May 1st. No others hatched from this lot, but from another collection made May 2d, two more females were secured from the pupæ on the

same day. These were the last emergences of this species, though hundreds of *canadensis* issued in the few days following. Adult captures were made May 25th, and seven more or less worn specimens were taken either upon the clothing or in the act of biting. A single female was sent in by Mr. Brakeley, who bred it May 2d, out of a lot of mostly *canadensis*.

Culex dupreei Coq. (Dupree's Mosquito).—The species occur with *C. serratus*, and like it, has not been taken during the past season. None of the pools where it occurred previously contained water at its proper time.

Culex trivittatus Coq. (The Three-Striped Mosquito).—Larvæ of this species, full grown, were taken at Madison, Morris county, May 8th, and again in the cedar swamps near Manahawken, June 15th. Both times they were associated with *C. sylvestris*. The early appearance of large larvæ with *sylvestris* of the same size would indicate that eggs are laid in fall and that the winter is passed in that stage. Adult captures in a very fresh condition were sent in from Madison September 1st.

Culex pretans Grossb. (The Brown-Striped Mosquito).—This mosquito, prior to 1905, was classed among the rare forms. It had been taken at various points in the State as an adult, but only once were larvæ found, and then only a few among a lot of *canadensis* and *sylvestris* in the Great Piece meadows.

In the season just passed it was again sought in spring, in the Great Piece meadows, and to our surprise was found in swarms with equal numbers of *canadensis*. This state of affairs occurred only on the north side of the Passaic river; on the opposite side *canadensis* was the dominant form, and not a single larva or adult of *pretans* could be found. (The meadow on the south side is a mile or so further up the river.)

Larvæ, full grown, were taken April 19th, in company with *canadensis*, a few *cantans* and a still smaller number of *aurifer*, *sylvestris* and *Aedes fuscus*. On the 21st pupæ began to form rapidly, and on the 23d the first adults, ten males and one female, emerged. April 24th, thirty-five males and eleven females emerged, and on the 25th, six males and eight females. Another collection, made April 24th, principally for specimens, turned up a lot of pupæ, and on the 26th, sixty-six males and three females emerged; the following day fifty-two males and fifty-two females, and on the 28th, six males and twenty-six females. Two or three specimens issued on the 29th, and

that proved to be the last of the brood. After *pretans* ceased issuing, *canadensis* began to emerge in large numbers. The eggs, it appears, hibernate and hatch simultaneously the following spring, the adults appearing a little before *canadensis*.

In Hartford, Conn., the species was reported equally abundant in the woodland pools, and the adults caused considerable annoyance in the southeastern portion of the city.

Culex inconspicuus Grossb. (The Inconspicuous Mosquito).—This mosquito, though sought where it has previously been taken, could not be found during the season.

Culex aurifer Coq. (The Golden-Scaled Mosquito).—Two specimens of the larvæ, the only ones sent in, came from the Great Piece meadows, April 24th, in company, as usual, with *canadensis* and with *pretans, sylvestris, cantans* and *Aedes fuscus*.

Culex pipiens Linn. (The House or Rain-Barrel Mosquito).—This was found breeding in all places suitable for its development. Young larvæ were found as early as May 8th, and from then continually to the end of the season.

Culex restuans Theob. (The White-Dotted Mosquito).—This was found with the preceding, and occasionally an entire brood would be *restuans*.

Culex salinarius Coq. (The Unbanded Salt Marsh Mosquito).—This heretofore common species was searched for again and again on the salt marsh, where it was known to breed, but not a single specimen in any stage was secured until early in November, when Mr. Brehme found it in some pools on the Elizabeth marshes, in company with *C. cantator* and *Anopheles crucians*.

Culex melanurus Coq. (The Black-Tailed Mosquito).—No specimens of this species were sent in or collected.

Culex territans Walk. (The Little Black Mosquito).—Some larvæ of this species were found in many fresh water collections. Mr. Brehme found them in considerable numbers at Arlington, August 12th.

Culex saxatilis Grossb. (The Rock Pool Dweller).—A medium-sized, black mosquito, with unbanded legs and beak. The thorax is marked with two pale, yellowish spots and the abdomen is banded with white at the apex of the segments.

Description of the Adult.

Female (Figure 5).—Measures 4. 7—5 mm.,=.19—.20 of an inch in length, not including the proboscis. The head is brown, with the occiput covered with yellowish-white scales and some dark brown ones; the antennæ and proboscis are dark brown, the former with

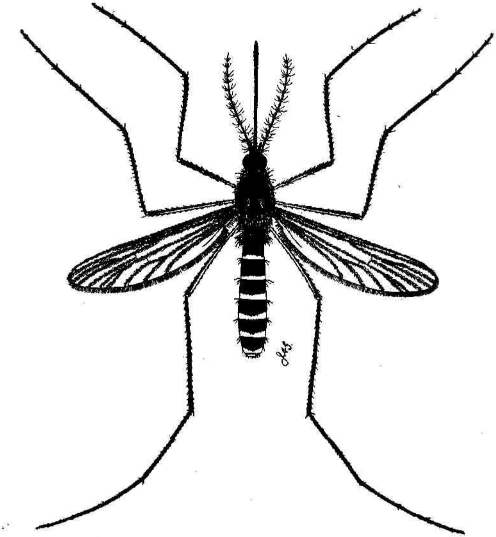


Fig. 5.
Culex saxatilis Grossb.: female adult; enlarged. Original.

scattered whitish scales; the palpi are brown, apparently three-jointed, the fourth being minute, pointed and wholly retracted within the third joint. The thorax is clothed with rich brown scales and pale, yellowish ones at the margins; two naked lines extend down the anterior part and two pale, yellowish spots, which become more or less

diffuse posteriorly, are on the center of the dorsum. The pleura are light brown with small patches of dirty, white scales. The legs are black, with the under sides and bases of the femora and a small dot at the knee creamy. The claws are equal and simple on all feet. The abdomen is dark brown, all segments with apical white bands, which widen out laterally, till, beneath, it is white with dark brown basal corners.

Habits.

This species was met with August 31st, in a rock-bottomed pool, on the Garret mountain, Paterson, in the pupal stage only. Some larvæ and pupæ of *C. pipiens* were in the pool at the same time, so it was not known that a new species had been taken until adults began to issue. Two females emerged on the same day of collecting, and September 1st, five others, all females, emerged, each time with *pipiens*, which, excepting one, were also all females. The last of the brood had been secured, the males having already hatched.

Uranotænia sapphirina Osten-Sacken. (The Sapphire-Lined Mosquito).—No specimens were taken in any stage during the past season.

Wyeomyia smithii Coq. (The Pitcher Plant Mosquito).—No effort was made to collect specimens of this species, though it undoubtedly bred in its usual numbers in the southern portion of the State.

NOTE.—The *Corethini*, formerly a division of the family *Culicidæ*, and embracing the New Jersey genera *Sayomyia*, *Corethra* and *Corethrella*, is now given family rank and is called *Corethridæ*.

They are distinguished from the *Culicidæ*, or true mosquitoes, by the comparatively short proboscis.

Sayomyia albipes Johann. (The White-Legged Corethra).—In the last report a belief was expressed that this species passed the winter in the larval stage. The evidence upon which this belief was based was the collection of a lot of almost full-grown larvæ at Paterson, October 3d, none of which showed any further development up to October 16th, when all were placed in alcohol. In the season of 1905 a few full-grown larvæ and pupæ were taken from a pool on Garret mountain, Paterson, April 18th, and a female emerged April 21st, thus removing all reasonable doubt as to its method of hibernation. It is also probable that they breed continuously throughout the season, as larvæ were taken again July and September, and adults bred from them the same year.

Sayomyia punctipennis Say. (The Little Spotted Corethra).—Two females of this species, one from Chester, August 1st, and the other from Delair, September 17th, were found among a lot of miscellaneous

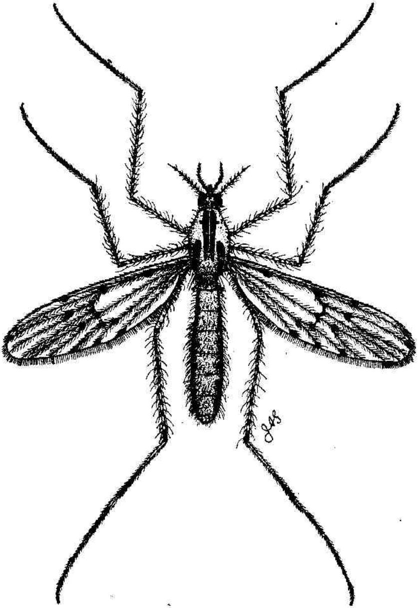


Fig. 6.
Sayomyia punctipennis Say.: female adult; enlarged. Original.

material in the Experiment Station collection. The only other record of its occurrence in this State is in the list of "Insects of New Jersey," by Professor Smith, where it is noted as occurring June 19th, at Riverton.

It is a small insect with three buff-colored stripes on the thorax, the median abbreviated posteriorly, the lateral abbreviated anteriorly. The wings are marked with about a dozen brown spots. The legs are whitish; the femora and tibiæ spotted with brown and the tarsi ringed with brown at the apex of the joints. The abdomen is yellowish-brown.

Description of the Adult.

Female (Figure 6).—Measures 3.5 mm.,=.14 of an inch in length. The head is yellowish, the eyes black and widely separated; the proboscis and palpi brown, the latter five-jointed and clothed with long, concolorous hair; the antennæ are yellowish, annulated with brown, and cream-colored hairs are at the base of the joints. The dorsum of the thorax is whitish with three longitudinal stripes, the median divided longitudinally by a narrow line which begins near the anterior margin and extends posteriorly for two-thirds the length of the thorax. The lateral stripes begin near the posterior margin and extend anteriorly to about the middle. The legs are creamy white, the femora and tibiæ each marked with about a dozen brown spots; the tarsi ringed with brown at the apex of the joints. The claws are simple on all feet. The wing veins are clothed with long, creamy scales, with brown ones collected in small spots as follows: at the cross-veins; at the point where the sub-costa joins the costa; on the radius midway between the point of origin and the junction with radius 2, where they touch the wing margin, and at the fork with radius 2 and 3; at the fork of media 1 and 2 and media 3; at the fork of cubitus 1 and cubitus 2, and also where they join the wing margin; on the first anal vein where it joins the wing margin. The abdomen is yellowish-brown, with black speckles laterally, scantily covered with concolorous hair on top, rather thickly at the sides.

Corethra cinctipes Coq. (The Ring-Legged Corethra).—Larvæ were taken occasionally in the early spring, always with the early stages of other species of mosquitoes. The fact that it has never been taken in fall by any of the collectors seems to show that it does not hibernate in the larval stage as does *Sayomyia albipes*.

Corethrella brakeleyi Coq. (Brakeley's Corethra).—Mr. Brakeley sent in hibernating larvæ and pupæ from Lahaway, where he collected them May 15th. Adults from this lot issued June 7th, when the culture was closed and the few remaining larvæ were placed in alcohol.